JANUARY 25 Cents

THE TECH ENGINEERING NEWS

IN THIS ISSUE

Indicators

Coolidge X-Ray

Civil Engineering

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

Better . . because IT'S WELDED

● The modern milk can is better because it's welded. Whether the can is made of aluminum or stainless steel—from the standpoints of cleanliness, sturdiness and serviceability—it is easy to see why the use of welded joints is beneficial.

Welding has made many good products better—milk cans, automobiles, airplanes, radios, refrigerators, streamlined trains and a thousand other things. This modern method of manufacture is applicable to the widest range of materials—steel and iron, aluminum, copper, brass and all other alloys and metals, even platinum. It is ideal for use where strong, smooth, invisible joints are necessary for enameling, for cleanliness or for appearance.

Tomorrow's engineers will be expected to know how to apply this modern metal-working process. Several valuable and interesting technical booklets describing the application of the oxy-acetylene process of welding and cutting in design, construction and fabrication are available from Linde offices in principal cities. Write The Linde Air Products Company, Unit of Union Carbide and Carbon Corporation, 30 East 42nd Street, New York, N. Y.

Everything for Oxy-Acetylene Welding and Cutting

LINDE OXYGEN • PREST-O-LITE ACETYLENE • OXWELD APPARATUS AND SUPPLIES

FROM PRODUCTS OF UNITS OF UCC UNION CARBIDE AND CARBON CORPORATION LINDE UNION CARBIDE

OUR AUTHORS

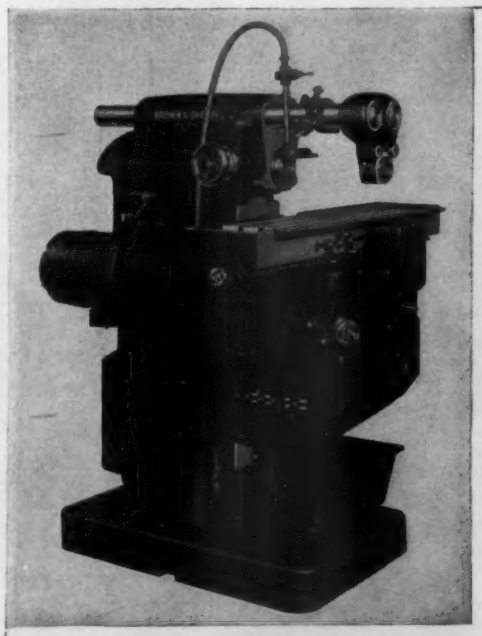
PROFESSOR JOHN B. WILBUR, '26, author of the article on *Civil Engineering*, is an Assistant Professor of Civil Engineering at Technology. He received his S.B. degree in 1926, his S.M. degree in 1928, and his Sc.D. degree in 1933, all from Technology. He has been a structural draftsman for the Maine Central Railroad Co., a bridge designer for the New York Central Railroad Co., and consulting engineer to the Timber Engineering Co., on the design of a 605-foot all-timber radio tower. He has also done considerable work for Fay, Spofford and Thorndike, Consulting Engineers, on the new continuous truss highway bridges over the Cape Cod Canal. During the last several years he has been developing, in conjunction with Dr. Vannevar Bush, Vice-President of Technology, a new machine for the solution of simultaneous equations.

MILLARD B. HODGSON, '39, who wrote the article on the *Coolidge X-Ray Tube*, passed away on January 24, 1937, at Phillips House. Born February 17, 1915, in Washington, D. C., he lived in Rochester until he came to Technology in September 1935. He was a member of the class of 1939, majoring in Physics. The class lost a valuable and well-liked member when he died. He was a member of the Phi Gamma Delta Fraternity, president of the Quadrangle Club, a member of the Freshmen Rules Committee, alternate president of the Class of 1939, a member of last year's freshman crew, and a staff member of *Voo-Doo*, The TECH ENGINEERING NEWS joins his classmates in their sorrow over his passing.

STEN W. WADSTEN, author of the article on *Diamonds*, was educated in New York City, and served his apprenticeship as a machinist with the De-la-Mater Iron Works. He is now employed as an Experimental Engineer and Assignor by the Westinghouse Electric and Manufacturing Co. For the last seven years he has been an Associate Member of the American Society of Mechanical Engineers, and also a Class Member of the American Society for Metals.

PROFESSOR FREDERICK K. MORRIS, Professor of Structural Geology at the Massachusetts Institute of Technology, and the author of the article on *A Scientist's Philosophy*, is a graduate of the College of the City of New York, where he received his B.S. degree in 1904. He was awarded his M.A. degree from Columbia, where he served as an instructor from 1916–1920. He has since spent much time in China, founding the Geology department at Pei Yang University, Tientsin. At the same time, during 1920 and 1922, Professor Morris was Geological Expert for mining and industrial interests in Shantung, Hupeh, and Chihli. In 1927 he came to Technology as an Assistant Professor of Structural Geology. Professor Morris is a member of the Geological Society of America, the American Association for the Advancement of Science, the Explorers' Club, Sigma Xi, and Scroll.

NORMAN L. LASCHEVER, '40, who wrote the article on *Indicators*, was graduated from Weaver High School in February, 1935. He is registered in Course XVI at Technology. His main activity is THE TECH ENGINEERING NEWS.



No. 10

PROVED DESIGN

——Another **NEW**

Electrically Controlled

BROWN & SHARPE

PRODUCTION MILLING MACHINE

• Ask for descriptive circular of the New No. 10 Plain Milling Machine for rapid manufacture of small parts.
Brown & Sharpe Mfg. Co., Providence, R. I.

Catalog of Complete Line on Request

B·S

CAMBRIDGE
POT GALVANOMETER

• This galvanometer is an inexpensive instrument with the sensitivity of a reflecting galvanometer and the ruggedness of a milliammeter. It requires no levelling or clamping and is accordingly well adapted for general laboratory use.

It is fitted with both a pointer and a reflecting mirror suitable for "null" point indications as well as for use with a lamp and scale. It is only one of many Cambridge Galvanometers.

OTHER CAMBRIDGE PRODUCTS

Moisture Indicators and Recorders — Physical Testing Instruments
Surface Pyrometers — Laboratory Insts. for A.C. & D.C.
Galvanometers — Engineering Instruments
Gas Analysis Equipment — Physiological Instruments
and other Mechanical and Electrical Instruments

CAMBRIDGE
INSTRUMENT CO INC

3732 Grand Central Terminal, New York City

His Contribution
TO SCIENCE

To those working in the well equipped laboratories of today, it is difficult to believe that there was a time not so long ago that so essential an instrument as the microscope was far beyond the reach of many.

Then a young man had a vision. At his instigation and under his personal direction the first Bausch & Lomb Microscopes were made . . . forerunners of the hundreds of thousands now in service. That man was Edward Bausch . . . More important still, he built an organization imbued with his own ideals of service and integrity.

Today, as a result, schools, hospitals, scientific laboratories and other institutions have batteries of optical instruments that far exceed in quality and performance any previous apparatus.

In the Bausch & Lomb Product you purchase today you enjoy the advantages that only years of experience and development plus rigid adherence to ideals can give. There is satisfaction in knowing that "for your purpose, no finer apparatus is available." Bausch & Lomb Optical Co., 635 St. Paul St., Rochester, New York.

Bausch & Lomb

STEEL
Hot Rolled Cold Rolled Structural

GENUINE NORWAY IRON

STAHLEKER STEEL CORPORATION

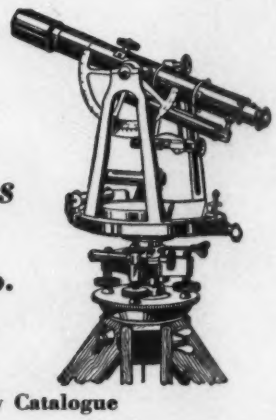
66 BINNEY ST., KENDALL SQ., CAMBRIDGE

TEL. TROWBRIDGE 1440

BUFF
TRADE MARK TRADE MARK

Superior

Surveying Instruments



Buff & Buff Mfg. Co.

Jamaica Plain, Mass.

Telephone JAMaica 0370

Write For New Catalogue

OKONITE INSULATION

OKONITE insulation with an unsurpassed record since 1878 is still generally recognized as the acme of perfection for rubber insulations and as "the best product possible" of its type.
The Okonite Company and its affiliates, however, have constantly kept step with the advances of the electric art.

Whether the wire or cable is large or small, single or multiple conductor, high or low voltage, whether finished with a rubber or a synthetic compound jacket, braid, lead sheath or armor of any type, Okonite can make it.

In all cases, whether the correct solution calls for rubber, impregnated paper, varnished cambric, asbestos, glass or the newer synthetic compounds, the policy still is and will continue to be *the best product possible.*

OKONITE

THE OKONITE COMPANY

Founded 1878

HAZARD INSULATED WIRE WORKS DIVISION

THE OKONITE-CALLENDER CABLE COMPANY, INC.

EXECUTIVE OFFICE
PASSAIC
New Jersey

FACTORIES:
Passaic, N. J. - Paterson, N. J.
Wilkes-Barre, Pa.

THE TECH ENGINEERING NEWS

JANUARY, 1937
VOLUME XVII
NUMBER 8

CONTENTS

THE COVER: TRANSPARENT WOMAN
Courtesy—*Pittsburgh Plate Glass Products*

FRONTISPIECE: ELECTRON POWER
Courtesy—*Electronics*

CIVIL ENGINEERING - - - - - - - 187
By Professor John B. Wilbur, '26

COOLIDGE X-RAY TUBE - - - - - - 190
By Millard B. Hodgson, Jr., '39

A SCIENTIST'S PHILOSOPHY - - - - - - 193
By Professor Frederick K. Morris

THE DIAMOND - - - - - - - - - 194
By Sten W. Wadsten

INDICATORS - - - - - - - - - 195
By Norman L. Laschever, '40

EDITORIALS - - - - - - - - - 196

ENGINEERING DIGEST - - - - - - - 198

RESEARCH IN REVIEW - - - - - - - 200

INDEX: VOLUME XVI - - - - - - - 205

INDEX: VOLUME XVII - - - - - - - 206

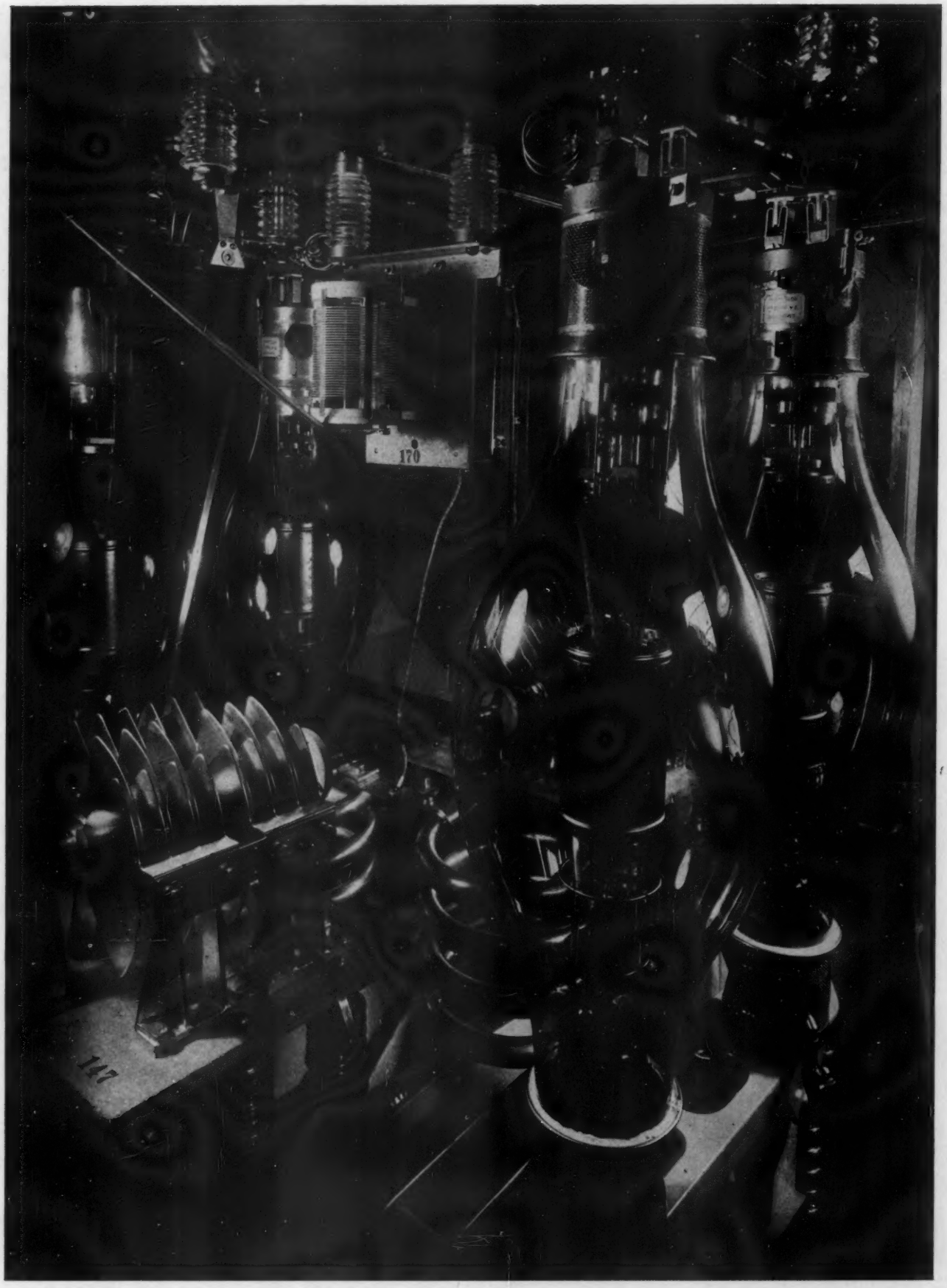
H. ARTHUR ZIMMERMAN
General Manager

JERVIS C. WEBB
Editor-in-Chief

FRANCIS S. BUFFINGTON
Business Manager

Technique

Published monthly throughout the school year, at Walker Memorial, Cambridge A, Massachusetts, by the undergraduates of the Massachusetts Institute of Technology for the purpose of disseminating news of scientific and industrial interest and of promoting closer co-operation between Alumni and undergraduates. Entered as second class matter, June 1, 1920, at the Post Office at Boston, Mass., under the Act of March 3, 1879. Acceptance for mailing at special rates of postage provided for in Section 1103, Act of October 3, 1917, authorized November 3, 1920. Copyright 1937 by The Tech Engineering News. Subscription per year $1.50. Foreign $1.75. Single copies 25 cents.



ELECTRON POWER

The Scope of the CIVIL ENGINEERING *Profession*

By JOHN B. WILBUR, '26
Assistant Professor of Civil Engineering, Massachusetts Institute of Technology

Hardly had the earliest mathematical and physical laws been discovered when the civil engineer became the applied mathematician and applied physicist of that early, rather highly organized civilization. Populous cities were supplied with water; roads and bridges were designed and constructed to transport building materials, and to facilitate colonization. Roman engineers were famous for their courageous construction of aqueducts of great length and height, tunnels, harbor improvements, monumental buildings, and roads extending all over Europe. Little happened during the eclipse of civilization in the Dark Ages, but in the Renaissance the civil engineer again began to construct cities and span rivers. Since the successful development of the steam locomotive, coming as it did on the heels of the industrial revolution of Europe, the world has more and more required of the civil engineer that he design and reconstruct better cities; supply them with water adequate for consumption, industry and fire protection; remove wastes safely; provide surface and underground transportation facilities; make the rivers navigable and the harbors safe; harness the rivers by building great dams to provide power to industry and light to mankind, and to safeguard against devastating floods.

The civil engineer blazes the way into new countries, but his highest technical ability is required in the operation of great cities and the transportation systems which link them to less developed portions of the globe.

C. B. BREED,
Dept. of Civil and Sanitary Eng.

THE scope of civil engineering has been admirably demonstrated in this country by a distinguished graduate of Massachusetts Institute of Technology who was consultant on the Panama Canal and on the Keokuk Dam across the Mississippi; organized a nation-wide fire prevention service for fire insurance companies; was president of six insurance companies; was consultant on water supply construction and investigation for Los Angeles, San Francisco, and Baltimore; was engineer for the Chinese Government on the Yellow River control project; became an authority on the design of buildings to resist earthquakes, and on engineering geology; and promoted the construction of our National Hydraulic Laboratory.

This partial list of varied activities of one great civil engineer suggests the almost limitless fields of service of the men of this profession. The "art of using the varied materials of nature and of directing the great sources of power in nature for the use and convenience of man" finds the civil engineer challenging and conquering basic problems of civilization on far-flung fronts. Monuments to the ingenuity of man mark his progress: bridges of unprecedented span; skyscrapers that tower above the horizon; gigantic dams wedged between the walls of deep canyons. This surpassing of previous accomplishment in creating works of new magnitudes borders on the spectacular, and weaves in popular fancy a cloak of romance about the civil engineer. The bronzed young transitman signaling to his distant rodman is, to many, the symbol of the profession. But the very proximity to every day life of the widely varying phases of civil engineering precludes, in most instances, the possibility of the spectacular. To appreciate properly the function of this profession, one must view the works of its members as a whole. From this point of vantage, the multitude of lesser accomplishments, covering a range of activities that defies adequate description in an abbreviated form, will become apparent, and in the assimilation of these many works the true significance of civil engineering may be discovered.

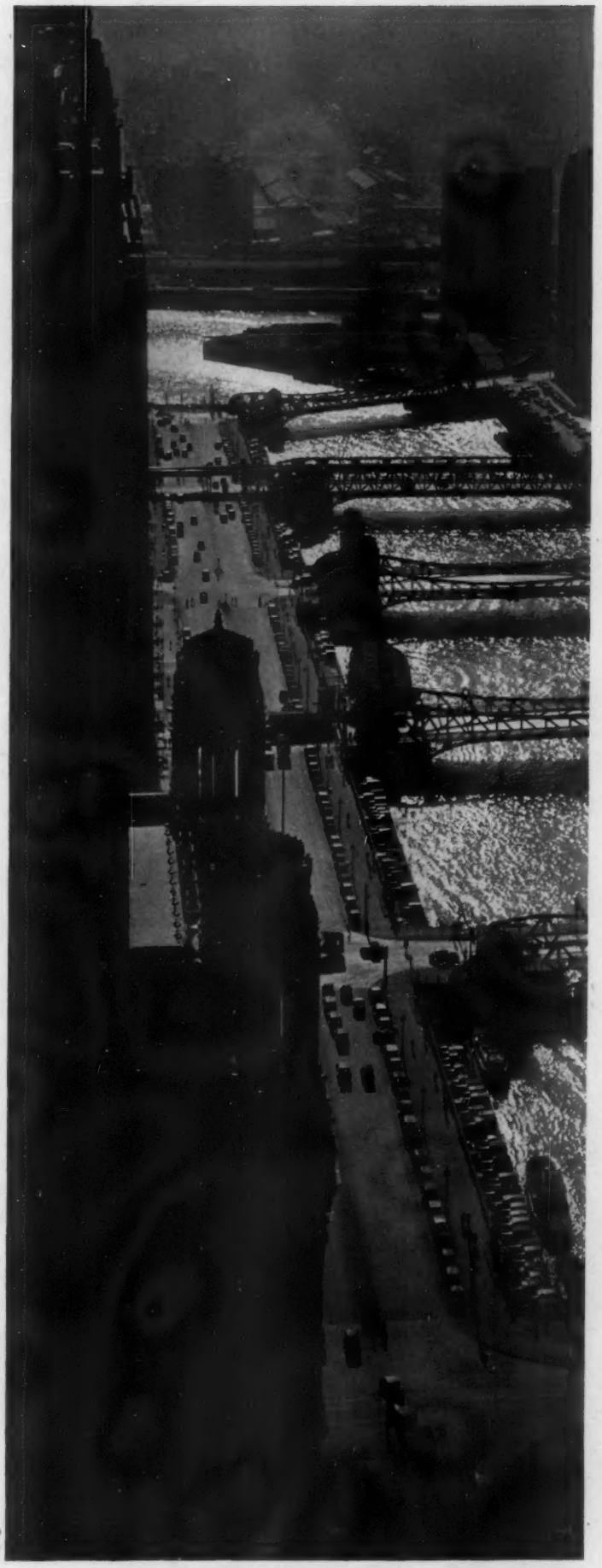
The more intensive the activities of the people of a community may be, the more they depend upon the civil engineer. Let us then examine a typical city of today: here we find the works of the engineers of the past being used; here, in the process of development and construction, are their present day projects; and, here also, may be found many of the problems which remain as a challenge to future civil engineers. Construction, transportation, sanitation, and power development—each so necessary to the development and existence of a city that it is a basic element in urban life—all call for the services of civil engineers. Suitable housing facilities must be provided to

—Illustrations courtesy Technology Review

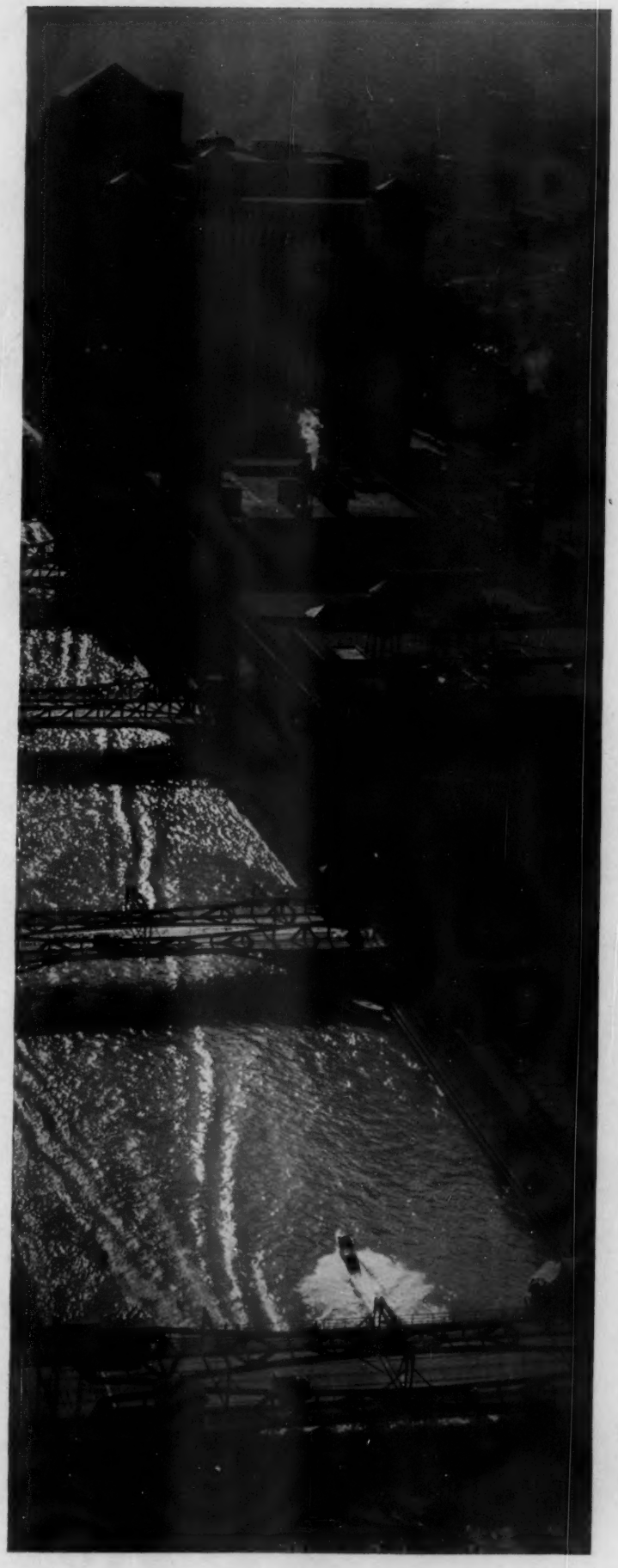
Boulder Dam: The structure essentially completed; the reservoir slowly filling.

protect the inhabitants of the city from the forces of nature, and, to enable the fuller utilization of surface area,multiple-storied units must be built. After men are thus brought together, adequate facilities for transportation of both men and materials must be provided. Living under congested conditions augments the need of sanitary provisions. Power available in nature, perhaps at some distance from a city, must be made available for light, transportation, and manufacturing. These problems cannot rightfully be considered separately, for each extends beyond its own borders to merge into the works of the civil engineer. Structural design, a phase of construction, for example, includes the structural design of buildings, which may be considered as being built for the direct utilization of their inhabitants; but the structural problems encountered in providing for transportation, sanitation, and water power development may form a large part of the work of the civil engineer who specializes in the structural aspect of civil engineering. Bridges and tunnels for both railway and vehicular travel, structural frames for aircraft, and docking facilities for navigation—these are but a few of the works of the structural engineer which have as their function the furthering of transportation. Dams for the storage of a city's water supply, aqueducts to convey the water to the city, and buildings in connection with water and sewage treatment plants—here the structural engineer works with the engineer specializing in sanitation to maintain the health of the people. Dams to provide proper head on turbines and to increase the minimum dependable flow of water by storage, structures to house turbines and generators, and transmission towers to support the cables which bring electric power to the city—these are among the structures needed in the hydro-electric aspect of civil engineering.

Although most civil engineers specialize in one of the broad subdivisions of the profession, all these branches rest upon a relatively compact body of principles. Thus, while civil engineering is the broadest in scope of the engineering professions, fundamental knowledge of mechanics, mensuration, and economics forms the basis for a large part of the technical development of the civil engineer. But, of perhaps greater importance, is the development of the character and mental habits of those entrusted with the grave responsibilities which are intrinsic to the profession. The civil engineer deals in realities. The ability to think clearly and plan carefully, and the willingness to assume responsibility are among his necessary attributes. The failure of an important structure may cause the loss of scores of lives as well as involve an economic loss of major importance. The expenditure of huge sums on transportation and sanitation projects carries with it a tremendous responsibility to those whose money is involved, as well as to society as a whole. Even minor tasks such as the detailing of a structural connection are important, for upon such details the safety of a structure depends. The development of these characteristics in the civil engineer, both in his professional training and practice, is of such importance that he may be called upon from the technical aspect of engineering to assume responsibilities in diverse fields. Graduates in civil engineering from the Institute have become manufacturers, bank presidents, insurance executives, editors, and railroad presidents, and have occupied governmental positions of great importance.



March of the bridges along Chicago River.



Civil engineering is the parent stem from which many of the other branches of engineering have diverged. This breaking down of engineering into its various phases is a natural outgrowth of the dependence of civilization upon technical knowledge and the consequent ramification of technical details. The fundamental principles upon which civil engineering is based still remain, however, as the bases upon which many other branches build their specialization. Structural knowledge, for example, is a major element in the background of the building construction engineer, the architectural engineer, or the aeronautical engineer. Future growth in the importance of engineering may accentuate the tendency to specialize, but the basic training of the civil engineer will continue, to enable him to prepare for his work.

In a country rich in natural resources, sparsely populated, and undeveloped industrially, economic pressure does not necessitate a high degree of technical development. Early hydro-electric developments in such a country, for example, might be limited to ideal locations where even low efficiencies would be profitable financially. Our first railroad lines made money even though they were neither planned nor operated efficiently. Expenditure for technical development might then be held to a minimum, or even omitted. Today, however, a large portion of the world presents a different picture. To obtain more electric power, less favorable sites must be developed, and older installations must be rebuilt. Transportation facilities must rely more and more upon economic considerations which can be evolved only by careful planning and study. The co-ordination of the various transportation facilities will occupy a position of increasing importance with the transportation engineer. Increased population will add to the problems of sanitation. New techniques of design and construction will be developed by the structural engineer. New materials must be used, which will be lighter and stronger than those of today so that they may perform their structural task without too much burden due to their own weight. Such materials will undoubtedly be more expensive per unit of weight than the structural steels commonly in use today. Their economic utilization will therefore require increasing technical knowledge. A better understanding of the properties of materials will be accompanied by a closer evaluation of the future behavior of structures. The claim will not be made that a particular bridge is well designed because it carries loads that are much heavier than were originally specified. The economic use of new light-weight alloy steels will be accompanied by a recognition of the fact that over-ample design is poor engineering as well as is inadequate design. If the supply of raw materials becomes limited, additional time will be spent in design so that more efficient use of a small amount of material will serve the purpose of larger amounts less efficiently used. The growth of city and regional planning will offer new opportunities to the civil engineer. Economic pressure will increasingly demand the services of those trained technically to build efficiently.

The contribution of the civil engineer to social and economic growth will increasingly be recognized: increasing responsibility in public affairs will inevitably result. The works of a given generation must be maintained and improved; the expanding needs of the future offer new fields of service which will continue to challenge the best men available.

In the distance is the Colossal Chicago Merchandise Mart.

Story of the

COOLIDGE X-RAY

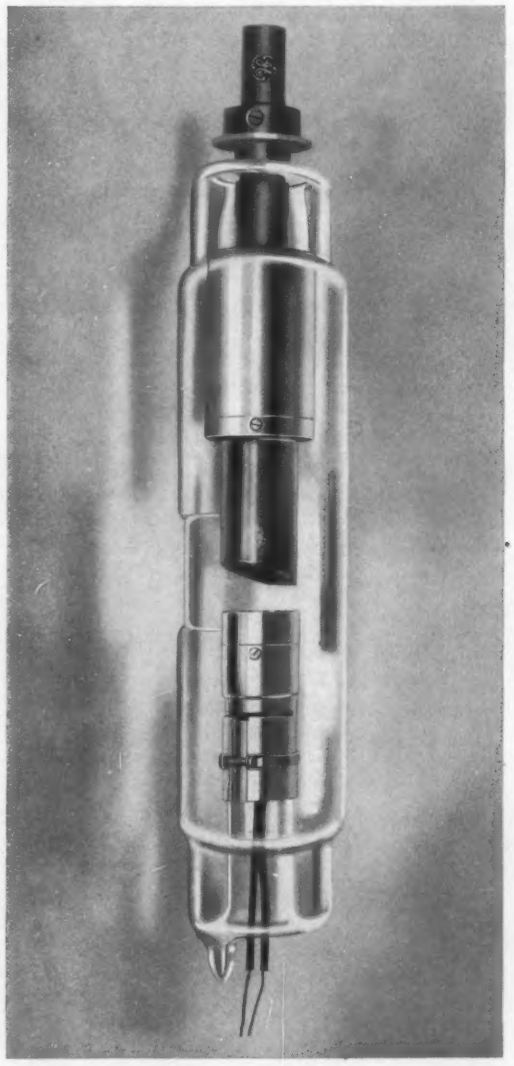
Tube

By MILLARD B. HODGSON, JR., '39
Massachusetts Institute of Technology

THE entire science of X-rays grew out of investigations of the phenomena occurring when an electric spark is passed through an exhausted glass tube. At low degrees of exhaustion, a luminous glow is seen to fill the tube. Tubes operating under these conditions are known as Geissler tubes. A common example of this effect is the modern neon sign, which is merely a commercial application of the laboratory Geissler tube.

In 1865, Hittorf, whose work was improved by Goldstein in 1867, found, when working with tubes exhausted to a pressure of about 0.1 mm., that a stream of rays emanated from the cathode, and traveled in a direction normal to the cathode to the opposite end of the tube. This phenomenon he called "cathode rays". In the eighties, Crookes produced tubes of greater exhaustion, and observed the "Crookes dark space" — a break in the striated luminous column which fills the tube when it is in operation. His research at this time led him to adopt the theory that these rays consisted of a stream of small negative particles, later called electrons. Sir J. S. Thomson in a paper, "On Bodies Smaller than Atoms", described a method of calculating the size of these particles, which, in the hands of R. H. Millikan and others, has yielded the figure of $\frac{1}{1840}$ times the mass of a hydrogen atom as their mass. Lenard introduced into the end of the Crookes tube an aluminum window which allowed these particles to pass out of the tube, so that their effect on different substances could be studied. The rays caused some substances to fluoresce, and would pass through air for several centimeters.[1]

—*Illustrations courtesy General Electric X-ray Corp.*



Dental X-ray Tube.

The work of Crookes, Thomson, and Lenard was followed by Roëntgen's discovery in 1895 of X-rays.[2] He observed that some invisible form of radiation emanated from the point in the tube wall where the cathode stream struck that was capable of causing fluorescence even after passing through a piece of black cardboard. The rays were also found to affect photographic plates. Being unable to understand the rays at the time, Roëntgen called them X-rays. Bequerel, two years later, found that the X-rays had no connection with the fluorescing of the tube wall at the point of impact, and were evolved by the impact of cathode rays on many substances, the heavy metals giving the best results.

In March, 1896, Sir Hubert Jackson designed the focus tube in which the cathode stream was focused on the anode by the use of a hemispherical cathode. The anode was placed at a forty-five degree angle with the electron stream, allowing X-rays to be taken off at right angles to the axis of the tube. This form, with some refinement, such as a mechanism for admitting small quantities of hydrogen into the tube, was the gas tube used until the introduction of the Coolidge tube in 1913.

This form of tube had many disadvantages. The character of X-rays evolved by it was entirely dependent on the degree of evacuation, the rays becoming less penetrating as the pressure increased. This meant that the rays emitted by the tube could not be depended on, for, when the tube grew hot during exposure, occluded gas was liberated, and the penetration or hardness of the rays decreased. There was no simple, accurate method of measuring the hardness of a tube except by the very fickle criterion of the color of the fluorescence observed on the tube wall. This uncertainty meant that even a good photographer must needs be little short of a magician to obtain the correct exposure. The current carried by the tube, and thus the length of exposure used, was dependent on the gas pressure and the applied voltage. Inasmuch as the voltage could not be accurately controlled on the available equipment, another variable was introduced. The tube could not be operated on alternating current; it was necessary to employ a rectifier in

[1] This experiment was recently repeated by Dr. Coolidge, using a tube of 1,000,000 volts potential, with which cathode rays were produced which would penetrate six to eight feet of air.

[2] It is interesting to note that Professor Cox of McGill University announced observation of the same rays a few days after Roëntgen's discovery without having heard of Roëntgen's work.

the power supply. The greatest limitation, however, was the fact that poor photographic materials made very long exposures necessary in order to take radiographs of even comparatively easily radiable material; an exposure of the head, for example, would require two or three minutes with the photographic materials then available. None of the modern work, such as deep therapy and industrial radiography of castings, would have been possible. Complicated, uncertain, slow—this was the state of X-ray technique at the time of Dr. Coolidge's patent.

William David Coolidge was born in Hudson, Mass., on October 23, 1873. In 1896 he was graduated from the Massachusetts Institute of Technology with the degree of B.S., after which he went to Germany and received his Ph.D. at the University of Leipzig in 1899. Returning to the United States, Dr. Coolidge joined the teaching staff of the Massachusetts Institute of Technology, serving first as assistant in physics, then as instructor in physical chemistry, and finally as Assistant Professor of Physico-chemical Research. In 1905, he joined the General Electric Co. as a physicist, with some misgivings. Today he is Director of Research.

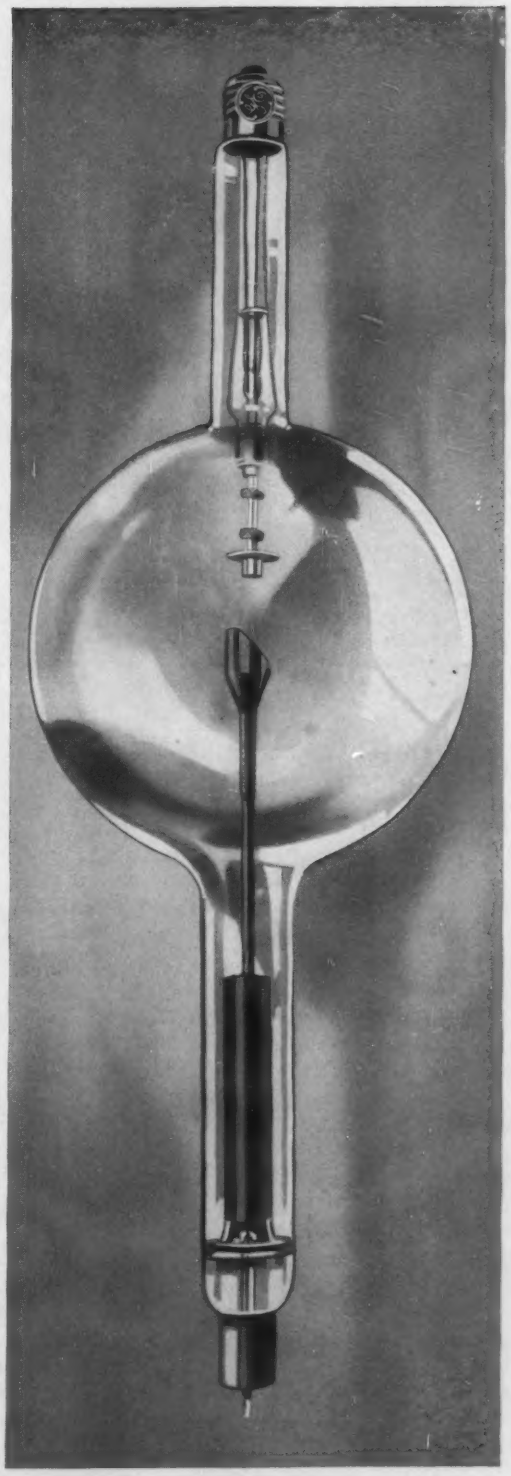
On December 30, 1913, Dr. Coolidge obtained a patent covering a process for making ductile tungsten, heretofore known only as a black powder. This patent was followed by a series of others covering various uses of tungsten.

The patent of October 31, 1916, relating to a vacuum tube is the one with which we are chiefly concerned. The vacuum tube patent will be discussed again in a later section.

In 1884, Edison found that a current could be carried between two wires in a vacuum if the negative wire was red hot and the positive cold. If the hot wire were made positive, and the cold wire negative, no current passed. The facts were that the hot wire lost some electrons into space, by an effect similar to the vaporization of water, and these electrons were attracted to the cold wire by the positive charge, resulting in the passage of a current. Much work was done on the "Edison effect" by Dr. Irving Langmuir of General Electric in 1913. This "Edison effect" is the basic principle upon which the operation of the Coolidge tube depends.

In the gas tube, the supply of electrons for the cathode ray stream is furnished as follows: Some residual gas was left in the tube when it was exhausted. This gas was ionized by the high impressed voltage. The positive ions thus formed were attracted to the cathode with great force, setting electrons free upon impact. The supply of electrons, of course, depended on the gas pressure, and the voltage was quite irregular. Dr. Coolidge realized that the Edison effect might make a very good source of electrons for an X-ray tube, as the tube could be evacuated to the point where it would not conduct electricity, and the proper amount of electrons for the cathode ray furnished by a hot cathode. He built a tube of this type, and obtained a source of X-rays that was quite reliable, as it did not have a critical pressure to maintain; and the supply of electrons was controlled merely by varying the temperature of the cathode. Inasmuch as the current would not flow from the cold anode to the hot cathode the tube was self-rectifying as long as the target was not as hot as the cathode. Dr. Coolidge applied for a patent on this tube May 9, 1913 and received his patent, containing thirty-three claims covering the design, manufacture, and use of the tube on October 31, 1916.

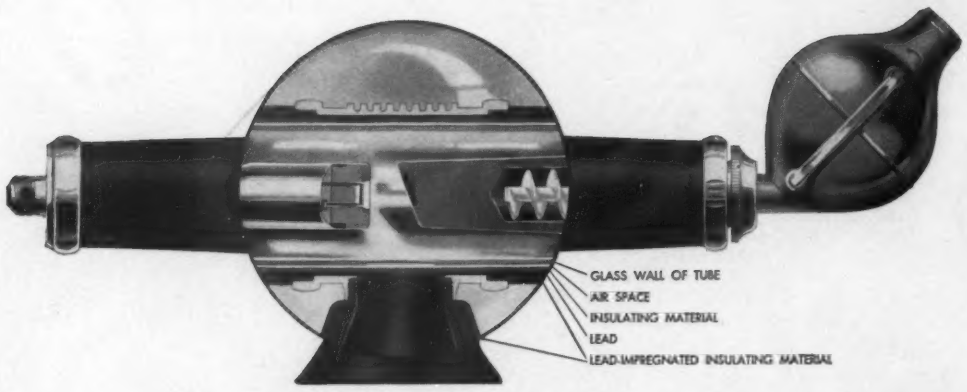
The validity of the patent was never contested in the United States courts. Lillienfeld in Germany claimed work on a hot-cathode tube, but never filed suit in the United States; perhaps because of the fact that the General Electric Company to whom the patent was assigned, claimed that the Lillienfeld tube infringed on the Coolidge patent. Several years before the expiration of the patent the Chemical Foundation of America threatened action, charging that the General Electric Company, through its monopoly, had withheld possible



X-ray Tube for general purposes.

advances in X-ray tube design and use. This complaint does not seem wholly logical, as most manufacturers realize the commercial value of improvements. No action was ever taken by the Foundation.

The advent of the Coolidge tube greatly increased the scope of radiology. It made X-rays reliable, simple, and easily controlled, and it made possible parallel advances in electrical equipment. The standardization of exposure in terms of simple physical measurements was made possible. Equipment of greatly increased power was developed, which, coupled with a considerable advance in the recording means,



made it possible to decrease exposures greatly, and to increase the range of application. Simplification of equipment, formerly operable only by specialists of long experience, made X-rays available to an increased number of hospitals and physicians. Interpretations of radiographs became the principal function of the radiologist; it was no longer necessary that he be, in effect, a trained physicist.

With this widening of scope has come the application of X-rays to many new fields. Tubes are now made that will carry 30 milliamperes at 200,000 volts, as compared with 20 milliamperes at 60,000 volts as the average peak for gas tubes. With this increased power, X-rays are now used in medicine, not only for diagnosis, but also for therapy. They are valuable in the treatment of skin diseases, and have been found to have an anodyne effect, stopping itching in some skin affections. In the treatment of tumors, X-ray therapy is of decided value, destroying the abnormal cells very well in some instances, although different types of tumors vary in radio-sensitiveness. In the treatment of cancer, X-rays are being put to very good use. In treatment of deep-lying cancers, an interesting technique has been developed. The tube is moved to several different positions in the course of the treatment, thus decreasing the length of exposure of the healthy tissue interposed between the tube and the infected area for any particular tube position. Experimental voltages as high as 900,000 have been used in experimental X-ray therapy; the resultant rays approach the wavelength of the gamma rays of radium.

In pure science, the manufacture of stable Coolidge tubes with molybdenum targets has made available a steady, reliable source of monochromatic X-rays, when used with a zircon (ZnSi) filter. Great advances in chemical and physical theory, particularly in the field of crystal study and the structure of the atom, have thus been made possible. Many chemical analyses are now made by X-ray spectroscopy.

With greater power and higher voltages—hence more penetrating rays—industrial radiography has been very much widened in application. Steel to a thickness of four inches has been successfully radiographed. X-rays are now in routine use in the examinations of welds and castings, the United States government using them extensively in the examination of shells and fuses, and in the inspection of airplane fabrication.

X-ray diffraction patterns furnish a reliable method of checking on the progress of heat treatment, and the strain condition of drawn or rolled metal. Complex castings of glass, hard rubber, or Bakelite are inspected by X-rays for internal flaws. Impurities in rubber tires or coal can be detected. Entire high-pressure oil and steam lines have been radiographed, as have the jackets of high-pressure steam turbines.

It is possible that in the future tubes operating at potentials of well over 1,500,000 volts will be available. The application of equipment of this power is a matter of conjecture. Perhaps even further progress may be made toward the solution of the problem of the structure of matter with the very short waves available.

Industrial X-ray Tube.

Glance At

PHILOSOPHY

With a Scientist

By FREDERICK K. MORRIS
Professor of Structural Geology, Massachusetts Institute of Technology

FIRST let us see what the good word Philosophy means: "You have fallen into the hands of the Jews, Eugene, says Mortimer Lightwood. "My dear Mortimer," returns Eugene, "Having previously fallen into the hands of some of the Christians, I can bear it with philosophy." Now here's one definition of the word: Eugene meant "stoicism" or "patience."

"My philosophy of life," says Foxy, the honored parent of Sampson Brass, "is, do others, for they would do you." And so we find another meaning of the word: "ethics," or "principle."

The philosophy of Solomon consisted of trite sayings, like "Too wise a son maketh a sad father," if I remember rightly my early training, and in this sense the word means "epigram," "analect," or "proverb." Kung Fu Tze, whom we call Confucius, was a philosopher of Solomon's breed, and as good as Solomon, who preceded Confucius by four centuries.

The many-sided Goethe offers as one of the Eternal Verities:

"Who loves not woman, wine, and song,
Remains a fool his whole life long."

Most of us subscribe to this philosophy; the trouble with it is that it's a two-way road: for there be some who have loved all three of these excellencies, and yet made fools of themselves.

Plato's philosophy was like Solomon's in some aspects, but it was also a speculative attempt to reach ultimate truth—to solve the riddle of the world. Most religions have also tried to be philosophies in Plato's sense by attributing the universe to the works of God.

All of these definitions of philosophy are correct, and all are in current use; but none of them content the philosophers. They wish to be called the summarists of knowledge; and in their hands philosophy is the science of sciences—choosing from each science its universally applicable fundamental truths and weaving them together into a consistent whole. Philosophy, they tell us, recognizes that the details of all fields of research change; but that each science reaches some permanent truths which are part of the web of philosophy.

Inevitably, the philosopher gathers in the methods of reasoning no less than the truths which are the result of reasoning; so logic becomes a part of philosophy. Methods of reasoning can't be separated from the mind that reasons, so philosophy annexes psychology. The structure of any philosophy must inherit important canons from the past philosophers; in some degree the present inter-weaves the conclusions of Descartes, Hegel, Kant, and fifty-seven others, so philosophy is in part history. The structure is already top-heavy.

To make matters worse, the philosophers find difficulty in applying to philosophy the scientific method of testing theories, exactly because it is a detail-method. We may test a theory in Geology by unscrambling the rocks; or in Astronomy, by raveling the braided light which the stars send us. These tested theories may form elements of philosophy, but they are parts of their respective sciences until philosophy weaves them together to form a synthesis. Exactly that synthesis is difficult to test; we may prove or disprove a theory within a science, where we can appeal to abundant facts. The test is hardly applicable to a summary of generalizations.

All modern philosophies, then, are in part scientific generalizations, borrowed from the results of objective research in the laboratory, the field, or the observatory, and in part speculative thinking of the philosopher himself, or of older philosophers whom he follows. Where the incompleteness of science leaves broad gaps in our knowledge, some philosophers fill them in with speculation, and darn the patchwork of the sciences into an integral tapestry. The fallacy of such reasoning is at once apparent. William Morris Davis gave the correct analysis of it long ago in a parable:

Brave, intelligent engineers were sent to explore an unknown country. Each party attacked the difficult land at a different place, and each made accurate surveys. Long before they were done a Summarist came, who collected their patches of map, laid them out on a big board, and filled in between them with drainage and topography of his own inventing.

How shall this completed map be valued? It is worthless, and has even destroyed the value of the patches of true survey that were woven into it. All who claim a part in science—and this includes philosophers—must steer clear of speculation. There is no harm in proclaiming a state of scientific ignorance when all the available facts are insufficient to solve the problem. For example, geologists are ignorant today of the origin of their own earth, not because we haven't studied the problem; not because we haven't amassed a great deal of accurate information; but because the available facts are insufficient to point to an acceptable hypothesis.

Philosophical contributions from each science include truths which affect the mode of reasoning in other sciences. Geology receives more from physics and chemistry than it gives; for all its theories must conform to the principles which these more fundamental sciences lay down. On the other hand, all biology is, by a humorous logic, an outgrowth of geology; for all plants and animals are made of exactly the same stuff that we find in the rocks, the water, and the air. Indeed we might stop with the rocks, for there is no atom in the body or brain of the ablest man that can't be duplicated in the rocks, and even in the igneous rocks; and besides, the water and air are merely those rocks that don't crystallize at the temperatures and pressures prevailing over most of our planet. There are some who deny our simian ancestry, but none may even question our plutonic derivation; we are clearly distal children of the devil, even if we disown our proximal forefather, the monkey. The derivation of all living creatures from anorganic geological beginnings is jointly contributed to philosophy from geology and biology. It gives us a physical monism—an insight into the "one-ness" of all that is on, in, and within our Earth. This monism does not deny the possibility of a dualism. The way is still open to anyone to believe in a soul that inhabits living flesh, or a life of the soul beyond the death of the body—but it puts that dualism in the realm of metaphysics, where it belongs, and quite outside of the realm of science. All philosophical reasoning about life must be based upon this concept of monism, and recently we have seen several striking examples of failure, even on the part of able and well-trained men, who have commenced their philosophical reasoning about biological life by neglecting this fundamental

(*Continued on page 202*)

The Utility of

THE DIAMOND

In Commerce

By STEN W. WADSTEN
Research Engineer, Westinghouse Electric and Manufacturing Co.

CHARCOAL sells at about $15.00 per ton; a diamond of poor quality is valued at $15.00 per carat, 151½ of which weigh only one ounce. Does it not require considerable imagination to believe that both charcoal and the diamond are composed entirely of the same element—carbon?

The purpose of this paper is to acquaint present and future day designers and inventors with the marvelous utility of the diamond in commerce. To the layman this gem is nothing more than a luxurious ornament. To the trained engineer it represents a useful and practical raw material from which a tremendous number of tools may be fashioned. Its utility in this respect will be taken up fully later.

Diamonds are found in blue ground, composed of a hard clay that so covers the stones with a film of blue that mine workers rarely, if ever, see them. In the Kimberly Diamond Mines of South Africa, this clay-like material gives up about one-quarter carat of diamond to every 1600 pounds of blue ground. All types of diamonds are found in this blue ground, ranging in size from those as small as bird gravel to those as large as a hen's egg. But size, of course, is not everything. Forty percent of all diamonds mined are useless to the trader as precious stones. This fraction, however, is manna to the dealer in industrial diamonds.

Minerals, in order to be suitable as gems, must possess certain qualifications. They must be brilliant, beautiful, durable, rare, fashionable, and portable. Seldom, indeed, does a single gem fulfill all requirements. A good diamond, however, has each of these properties to a marked degree, and is, accordingly, most esteemed among precious stones. No one questions its supremacy. Historical diamonds, such as the Kohinoor (Mountain of Light), have long since established the diamond in its present position.

The Junkers diamond, about the size of an egg, is now being cut. It is freely predicted that when finished, it will be the most beautiful gem in the world. All cutting done on the stone will be done with commercial diamonds, for nothing but a diamond could be used to cut another diamond. The Junkers will be sawed with a bronze disk charged with diamond powder. This powder, called crushed bortz, is made from the poorest of all industrial diamonds.

The preparation of bortz is an interesting one. The low grade diamonds are placed in a special, hardened steel mortar. A hardened steel pestle is then struck repeatedly with a heavy mallet until the diamonds are completely crushed into powder. The powder is then graded in oil or carbon tetrachloride by a special flotation process. Since it is so sharp, the powder will, when applied with a roller, readily imbed itself around the edge of a bronze disc. The saw is now ready for service, and will cut the most stubborn materials. Even carboloy offers little resistance to it.

A diamond die is merely a commercial diamond with a fine hole through the center. Such a diamond is widely used, and is extremely valuable for the drawing of wire. A steel die of the same specifications would not hold its size long enough to be practical. To drill the required hole in the diamond die about 100 hours of drilling are necessary. Nevertheless, the demand for diamonds of about one carat size and of a quality suitable for wire-drawing dies is responsible for a great majority of all the commercial diamonds in use to-day. An illustration of their employment is given in the electric light bulb. The thread-like filament used in all bulbs is drawn through the hole of the die repeatedly, until it is reduced to .001 of an inch in diameter, approximately one-half the thickness of a human hair. No other tool is so durable or gives such uniform thickness of wire.

Commercial diamonds of inferior quality are also used as cutting edges for rock boring tools. Still other applications for diamonds are found in the drills which the dentist uses and in bearings for watches and electric meters.

Not all diamonds used in commercial work are stones which are too imperfect to be sold as jewelry. Instruments such as the Hardness Testers, the Schleroscope, the Brinell, and the Rockwell require diamond contact points. So flawless and so durable as to stand up under all kinds of use and abuse must these points be, that they can only be selected from scraps or splints taken from large gem stones. These scraps are first turned or boutted in a lathe with another diamond pointed tool, then finished to a well defined radius. Such a point costs about $35.00 to replace.

It is surprising with what ease a diamond tool will cut hardened tool steel. For feeding tungsten wire endwise into a die cavity, a hardened steel feed roll of ½ inch diameter is necessary. The diameter of the tungsten wire used in this case is .0016″ in diameter. This round wire must be held very tightly between the top and bottom rolls. Needless to say, this calls for a very accurate machining job after the rolls have been hardened. These hardened tool steel rolls require not only a perfectly smooth finish, but must also run absolutely true, inasmuch as a semi-circular groove must be turned in both the top and bottom rolls. The groove in each case must be something less than one-half of the .0016 of an inch, which is the diameter of the wire, or the rolls will not function at all. Only a commercial diamond tool will stand up steadily while constantly turning the hardened steel.

A number of manufacturers have not realized yet that commercial diamonds may be of great value to them in their operations. Actually, they may be used as hard facings in any process during which wire comes into constant contact with the facing. Automatic wire working equipment, such as tool steel jaws, may all be equipped this way. Especially are the diamonds valuable where a uniformity of product is essential. A gripper jaw, in which two wires of different material are held in perfect alignment while being united by welding, calls for diamond facings.

An idea as to the possible future development of the diamond in commercial machinery is best given by an illustration. In one well-known manufacturing plant a comparative parallel test run was started in a wire products division. One set of hard facings, using the diamond in its construction, has been in constant service for over six months with no signs of wear. All other types of facings used have to be revamped after each day's run. This, then, is a new and valuable function of that most beautiful of all gems—the diamond.

pH Control by

INDICATORS

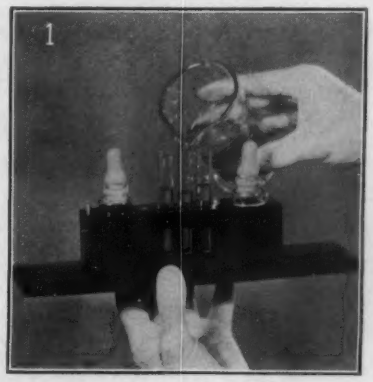
—*The Chameleons of Chemistry*

By NORMAN L. LASCHEVER, '40
Massachusetts Institute of Technology

PERHAPS, when younger, you wondered why a blue piece of paper turned red upon being placed on your tongue. Perhaps you were mystified by the experiment of pouring two colorless solutions together to produce a blood-red one. The magician in the side show blatantly announces that he has produced blood from water. The chemist simply recognizes a member of a most important class of reagents, the indicator. Indicators are substances, usually of complex structure, which change color in solutions of different chemicals. The two indicators mentioned above are no doubt the most commonly known of all. Litmus paper, both red and blue, and phenolphthalein have been used by nearly every student of elementary chemistry, so much so, that whenever the word indicator is used, these two are instinctively thought of.

The composition of litmus is interesting. Certain species of lichens, mainly "Roccella" and "Lecanora," contain an orcin from which litmus is obtained by oxidation of the orcin in the presence of ammonia. The coloring matter of litmus is a complex from which several compounds, of which azolitmin is the most important, have been isolated. Although several natural organic indicators, such as litmus, cochineal, and red cabbage extract are used, the present trend is towards the use of synthetic indicators. Acid cresol red, thymol blue, benzo yellow, bromcresol green, meta cresol purple, and methyl orange form a list, quite incomplete, of synthetic indicators. Each has its definite turning points, and each is useful in its limited range. Now, the word "indicator" has been rather promiscuously used all through this paragraph. Perhaps some one asks the question, "indicators of what?" Indicators are used to determine the pH concentration of solutions.

pH may be defined as the logarithm of the reciprocal of the hydrogen ion concentration, or as the log to the base ten of the number of liters of solution which would contain one mole of hydrogen ions. Now, just what does this mean? There are several methods of showing the strength of solutions, a common one being to cite the normality of the solution. This gives the total amount of hydrogen in an acid, for example, but in no way shows the total amount of hydrogen available at any specific time for a reaction. That is, there are degrees of strength of acids or bases. pH shows this degree. When certain substances called electrolytes are dissolved in water, they dissociate to a certain extent into ions. Water is very little ionized, and on the pH scale is neutral; nevertheless it does ionize to a small extent. It is apparent that increasing pH means decreasing acidity, or increasing basicity, and vice versa. At the two extremes are the strong acids and strong bases, and water is in the middle.

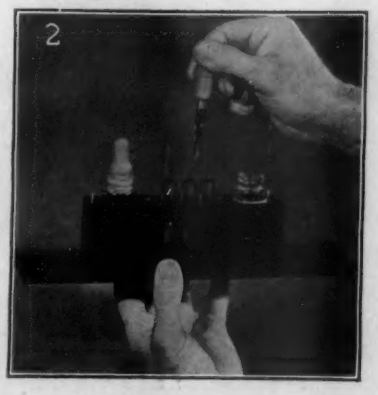


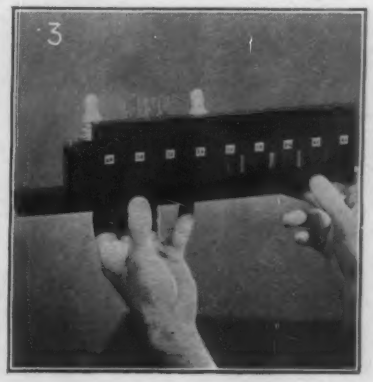
The value of the pH system, first suggested by Sorensen in 1909, is manifold. How much easier it is to say that a solution, 1-normal sodium hydroxide for instance, has a pH of 14, than to say its normality of hydrogen ion is .000,000,000,000,01 (1×10^{-14}). The pH of any solution, acid, base, or salt, can be figured out by using the formula $pH = \log [H+]$.

What is the behavior of indicators that makes them so useful in determining pH? It is their color changes that render them so useful. Extensive tests on various indicators have been carried out so that it is now known with certainty just what color will be exhibited by certain indicators in various ranges of pH. Indeed, it is possible to make a mixture of indicators so proportioned as to cover the entire range from 0 to 14, the various values of pH being recognizable from the color of the solution. As a rule, however, indicators are used to cover a limited range, so as to make a more exact determination possible. Litmus, with a range from 4.5 (red) to 8.3 (blue) is obviously useless in determining pH values between 4.5 and 8.3.

(*Continued on page 202*)

Illustrations courtesy W. H. Taylor Co.





Three steps showing how a pH determination is made using a slide comparator.

THE TECH ENGINEERING NEWS

THE MANAGING BOARD

H. Arthur Zimmerman, '37
General Manager

Jervis C. Webb, '37
Editor-in-Chief

Francis S. Buffington, '37
Business Manager

Frank B. Kemp, '38
Managing Editor

Robert L. Johnson, '38
Treasurer

Harry O. Saunders '38
Associate Editor

Richard A. Novak, '38
Advertising Manager

James B. Hess, '38
Associate Editor

John C. White, '38
Circulation Manager

Walter F. Kaufman, '38
Publicity Manager

Editorial Department

James H. Owens, '37
Contributing Editor

Amos J. Shaler, '39
Assistant Editor

Joseph J. Donovan, '39
Assistant Managing Editor

R. Dixon Speas, '39
Assistant Editor

Monarch L. Cutler, '39
Assistant Managing Editor

Harold Chestnut, '39
Assistant Editor

Irving Peskoe, '39
Assistant Managing Editor

Business Department

Robert S. Laird, '39
Assistant Advertising Manager

Augustus A. DeVoe, '39
Assistant Circulation Manager

George D. Cremers, '39
Assistant Publicity Manager

Thomas E. Langs, '39
Assistant Circulation Manager

John C. H. Lee, Jr., '39
Assistant Publicity Manager

Paul B. Farwell, '39
Assistant Treasurer

Charles N. Levy, '39
Assistant Advertising Manager

Staff

B. W. Wheeler, '39
C. G. Lenk, '39
G. Laurent, '39
F. Mulberry, '39

THE ENGINEERING COLLEGE MAGAZINES ASSOCIATED

Chairman, Professor Richard W. Beckman
Iowa State College, Ames, Iowa

Arkansas Engineer
Colorado Engineer
Cornell Engineer
Illinois Technograph
Iowa Engineer
Iowa Transit
Kansas Engineer
Kansas State Engineer
Marquette Engineer
Michigan Technic
Minnesota Techno-Log
Nebraska Blue Print
New York University Quadrangle
North Dakota State Engineer
Ohio State Engineer
Oregon State Technical Record
Penn State Engineer
Pennsylvania Triangle
Purdue Engineer
Rose Technic
The Tech Engineering News
Villanova Engineer
Washington State Engineer
Wisconsin Engineer

EDITORIALS

THE ETHICS OF SCIENCE

EVER since he began to become educated, man has gradually developed a number of "gentlemen's agreements" in his conduct of social life. Today, these "gentlemen's agreements," now known as "ethics," have reached a stage of conflicting complexities. Our institutions of society have become so interwoven that any ethics existing in one field, such as science, may overlap and even contradict the ethics recognized in another field, such as business. Thus, in their close contact with the business world, where "anything goes," the ethics of science are given the chance to become tainted. Their position resembles good fruit that has been placed in a basket of bad fruit.

Scientists may be roughly classed into two groups: those doing scientific research with pecuniary motives, and those doing research for a more idealistic purpose. Doubtlessly, it is the first category that is assailed whenever the ethics of science, or better, the ethics of scientists are discussed.

People point out that inventors of machines indirectly cause laborers to be thrown out of work, meanwhile enriching themselves by the accrued profits of the machine. For years, the cry of mankind has been to lighten his burden; but when a machine comes along and does that very thing, his cry is turned in a different direction. When Faraday discovered that a moving magnet in a coil of wire induced a current of electricity in that coil, did he know that some day tremendous power stations would make electricity to run factories that would, in turn, cause overproduction and unemployment? Was the person who discovered mustard gas actually looking for a poisonous gas? Can he be rightfully accused because war departments disregard international agreements and resort to the use of poisonous gas on the feeble excuse that it would cost the enemy less men to be defeated quickly in this way than to be conquered by the prolonged methods of fighting with bullets? Finally, although the conscience of Nobel was deeply disturbed, can he be considered responsible for all the uses to which dynamite has been put?

The scientist who makes a discovery cannot be blamed for the public uses which his discovery receives. If it is our desire to fix the responsibility for the bad effects of science, let us look to those who use science, to those who control its use. Too often the scientist sees his years of work developed selfishly by business principles that benefit the industrialist. His purpose is defeated because the industrialist sees the advantage to society only as a by-product, or as a force that will

lead society to purchase the goods he produces. The scientist should not be blamed for the social system in which he finds himself.

The responsibility of the scientist to society does not lie in any presumed condition that he is the cause of social ills. His responsibility, his ethics, must evidently be based on some higher law, corresponding perhaps in some manner to those of a doctor. He has thus far in history been willing to give freely his time and invaluable efforts, and then view from the background where he has been pushed, the application of the product of his ingenuity as a relentless instrument of wealth and power; a great part of the men of science are but minds subsidized by large corporations. The desire to take part in the application of the products of their minds to the needs of society is a new trend that is only just starting. The case of the Rust brothers, who will not give eager speculating industrialists the opportunity to market their cotton picker without thought to its social effects, has been justly publicized. Perhaps it is a new trend in technical education that has led to this new ambition of scientific men. Perhaps the scientist is awakening to his responsibility—the responsibility of any intelligent and capable individual to be aware of the condition of the world around him and to do what he can to make that world a better place in which to live.

EXPANSION

SINCE Lindbergh flew the Atlantic in 1927, the airplane industries have shown a remarkable upward trend. The total number of firms in the United States have more than doubled; airplanes in operation have increased in number by three-fold; miles flown by private and commercial flyers are more than four times as great; air-mail poundage shows four times the weight flown in 1926. The biggest gain, however, has been in the number of passengers carried by the scheduled air lines: the number of passengers carried in 1936 being 180 times the number transported in 1926. Figures for the current year predict an even larger volume of business, for the totals are running well ahead of those of last year.

In this period when most of the nation's industries has been experiencing a contraction in their volume of business, civil aeronautics has shown a definite expansion. The service rendered by the air lines has proved so valuable that even in the face of a general business depression these industries have continued to expand. They provide America with its fastest method of transportation. Moreover, safety has not been sacrified to gain this speed; today, air travel is safer than motoring. Traveling comfort has improved considerably. The advance from the open cockpit to the luxurious comfort of the new sleeper planes represents a great advancement Improved designs in airplane construction are manifest by the mere comparison of the photographs of the airplanes of a decade ago with the ones of today.

It is almost certain that in the future the civil aeronautical industries will continue their record of achievement. They possess many potentialities of public service as yet unused. They have shown their ability to make improvements in their equipment. With this combination of enterprise and usefulness they have a future as promising as their past has been successful.

PAYING FOR TRAINING

IT is a well known fact that, unless he is on the squad, a student cannot play tennis on the Institute courts without paying for that privilege. We do not wish to infer that Technology desires to profit from this sport, nor do we believe that the money obtained entirely covers the cost of upkeep of the courts. If the charge is to place a limitation on their use, so that they shall not be overcrowded, the fact shows that more courts should be built. Technology is not in such a poor state financially that it has to rely upon the sum obtained from tennis players to help support the game. There is no justifiable reason for levying such a charge upon the students.

Tennis is not the only sport that has a tax of this sort. If a man, even though he may be out for crew, wishes to have a workout in one of the one-man shells, or "wherries," he has to pay thirty-five cents an hour for the privilege. It is not feasible that any one who pleases should be allowed the use of these "wherries," but it is conceivable that a man on the squad should be allowed all facilities available without charge.

Another question that might be raised is why does the Institute single out tennis and rowing for pecuniary demands? It is not insinuated that other such charges should be made, but rather that unless suitable reasons can be given for the tax on the use of the tennis courts and the "wherries," such charges should be entirely eliminated.

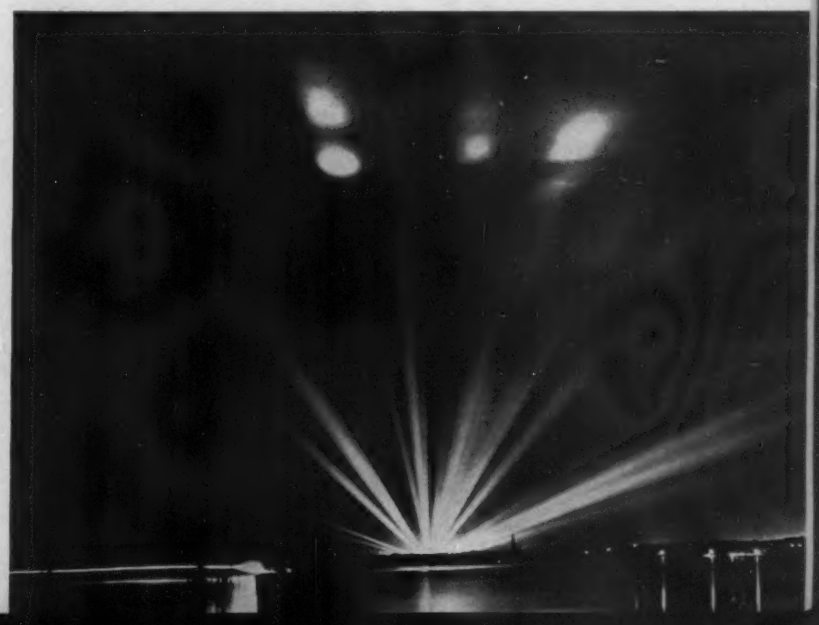
ANNOUNCEMENT

WITH this issue, the Managing Board of Volume XVII completes its work. Therefore, it is happy to announce the election of the following men to the positions on the Managing Board and Staff for Volume XVIII:

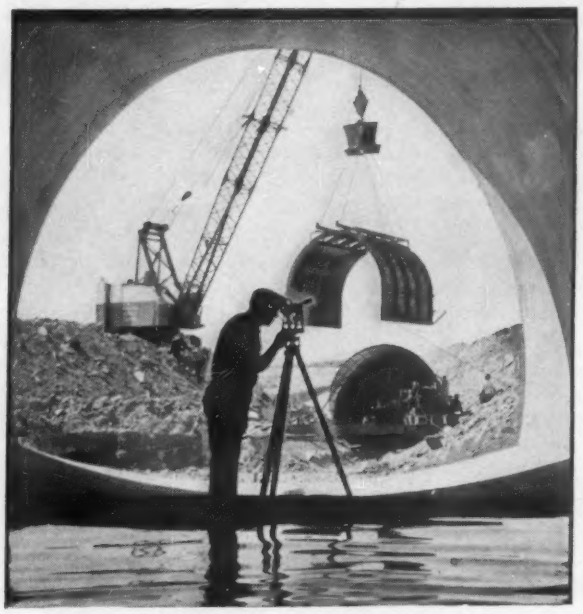
General Manager, Harry O. Saunders, '38; Editor-in-Chief, Frank B. Kemp,' 38; Business Manager, Richard A. Novak, '38; Managing Editor, Joseph J. Donovan, '39; Associate Editors, R. Dixon Speas, '39, and Monarch L. Cutler, '39; Treasurer, Paul B. Farwell, '39; Advertising Manager, Robert V. Smith, '39; Circulation Manager, Augustus A. DeVoe, '39; Publicity Manager, John C. H. Lee, Jr.,'39; Staff Manager, Samuel E. Hutchins,'39; Contributing Editor, Irving Peskoe, '39; Associate Publicity Manager, George D. Cremers, '39; and Associate Advertising Manager, Robert S. Laird, '39.

The following Freshmen were elected to the Staff: Paul M. Butman, Samuel P. Card, Harry N. Cottle, Jr., Frank G. Denison, Jr., Gordon A. Fairbairn, Raymond G. Foster, Oliver H. Fulton, James L. Jones, Norman L. Laschever, Lester Lees, John G. Leschen, Fred P. Lobban, Frederick E. Lykes, Jr., John M. McKee, Jr., Monroe L. Norden, Schrade F. Radtke, James S. Rumsey, Jack H. Schaum, and Eugene S. West.

—Courtesy Electronics



ENGINEERING DIGEST



DESERT AQUEDUCT

ON the Pacific Coast, in Southern California, there has been evolved a great civilization, one which has sprung to maturity in a comparatively short time. Its rapid growth has rendered inadequate the water supply system from the Sierras, and it became necessary, three years ago, to find another source if seven million people were to continue existing on the land they occupied. Stretching from a point on the Colorado River, 155 miles below Boulder Dam, across desert wastes, tunneling through mountains and under streams, a great aqueduct will, within three years, carry water to Los Angeles, Burbank, Glendale, and many smaller cities and towns in the surrounding region. With a billion gallons its daily capacity, it will be the greatest project of its kind in the world.

The engineers plan to complete the feat six years after its beginning in 1933. Such an undertaking could never be completed if it were not for the utilization of every known mechanical construction device, and even of some not previously known. Working under pressure, the engineers invented a pair of mechanical hands, which pat the liquid cement faster and more efficiently than any fifty pairs of human hands, doing the job at the rate of a thousand feet per day. It is only by the use of such unique mechanisms that the "river in the desert" will be brought to completion.

The treacherous desert presented problems which had to be solved if the project was to continue. The danger that the peculiar rivers of the desert might one day destroy the aqueduct was eliminated in a novel manner. Huge, inverted siphons will carry the water under the channels, so that the walls of water which rush down from the adjacent mountains after every cloudburst do not disrupt the supply system. The terrific winds, corrosive alkalies, and excessive heat of the desert would allow the use of no ordinary cement. To exclude air holes, which naturally weaken the structure, the seven million barrels of regular cement were ground to extreme fineness, resulting in the closest knit construction of its kind in the world.

This modern marvel provides many points of interest. With the cement used to build the walls, a walk, six feet wide, reaching from Los Angeles to Buenos Aires, could be constructed. The great *Queen Mary*, in a lifetime of voyages, could not carry in her spacious hold the excavated material.

—Popular Mechanics.

MODERNIZED PULLMAN

A LIGHT-WEIGHT, two-body passenger car has now been completed for the Pullman Company, and is being put into service on various regular trains throughout the country so that public reaction to the many new features may be studied. This car (shown below), and another, now under construction, are to demonstrate high-speed, light-weight equipment.

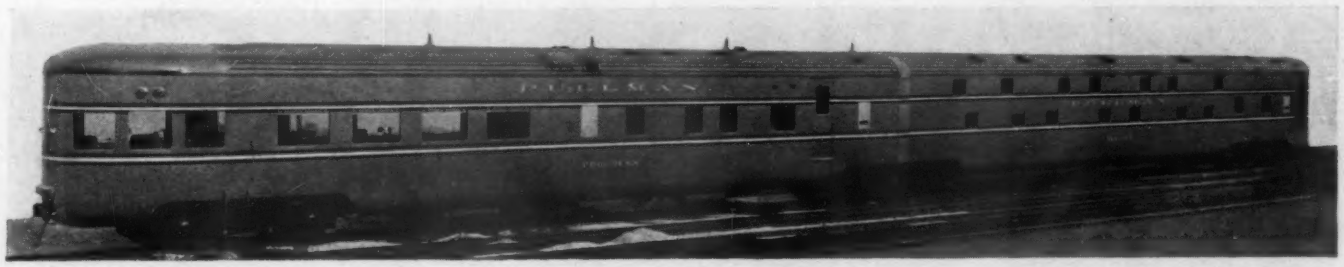
The structural frame and outside plates are made of a light-weight steel alloy, and the finish of the interior and the fittings are of aluminum. The cars are of standard Pullman width, and are articulated. There is one truck under the adjoining ends of the two car bodies, or three trucks in all for the entire unit.

The first car of the unit is of the Duplex type, containing fifteen single bedrooms, eight of which are on the upper level, and the remainder on the lower. Each room is complete in itself, having individual lighting, heating, and toilet facilities. During the day, the bed will serve as a couch. The cars are air-conditioned, an adaptation of the Pullman-Standard system.

The rear section contains several rooms, a buffet for light refreshments, and a lounge, the latter extending to the rounded end. In the foreward hall of this section, there are four double bedrooms. The lighting of both cars is both direct and indirect. The furniture is designed for comfort, and is in harmony with the rest of the decorative scheme.

It will be interesting to note the public's reaction to this latest improvement in the railroads. Practically all the latest developments in this mode of transportaton have been met with approval. This should be no exception.

—Railway Mechanical Engineer.



TRANSPARENT WOMAN

THE difficulties experienced by public health education associations and medical authorities in presenting three-dimensional models of the human body, with all the organs in proper relations, for purpose of instruction, have at last been obviated. Created in Dresden, Germany, of cellhorn, a new material as hard as horn and more transparent than glass, there is now touring the country on exhibit an exact reproduction, down to the most minute nerve and blood vessel, of the female of the human species. This is not the first of the models, for there have already been constructed by the group of scientists at the Hygiene Institute, four "glass" men, one of which was brought to this country by the famous Mayo brothers, attracting a great deal of attention at the Century of Progress Exhibition. Owing to the greater physical complexity of Woman, however, it was thought wisest to delay its construction until experience had been gained. The fruits of this experience are demonstrated to a marked degree in this first "glass" lady, which is illustrated on the front cover. An internal lighting system permits the lecturer to throw attention upon a single organ, upon the bone structure, or upon the nervous system at will, revealing them in greater detail than a fluoroscope. Each integral part is absolutely accurate in size, color, and position, so that a vivid picture of the human anatomy is gained, and interest thereby stimulated.

The task of constructing the unique model, which required eighteen months to complete, began with the projection upon a screen of photographs of small sections of the human body, from which artists made hundreds of drawings picturing every detail.

The sculptors were then called in, and, under the supervision of medical authorities, molds were made for the various sections, which were then fabricated in cellhorn. The assemblage was, understandably, the most difficult part of the work, and many months were consumed in perfecting the intricate arrangement. At last, however, the cellhorn skin was fabricated over the model and the "glass" lady took her place as an ally of good health. It is generally believed by members of the medical profession that the possibilities of the "glass" models as powerful influences in combatting disease by combatting ignorance are great. Obviously, a glass model revealing with such detail every feature of the human machine will hold the attention of the onlooker who was undoubtedly mildly bored with the previous structures, which were merely museum pieces. The system of illumination clarifies the anatomical structure still further, so that the average layman has little difficulty in comprehending what had previously been unintelligible to him.

The glass lady is to medicine what the planetarium is to astronomy. A man who refuses to plod through page after page of technical language which he cannot understand, not being well versed in the sciences, is spellbound by the wonders which he sees projected upon a hemispherical dome. The appeal to his visual sense is successful, and he becomes interested in astronomy. The glass lady serves a similar purpose. "Woman, know thyself," is no longer an empty phrase, but takes on a new meaning in the world of medicine.

The photograph on the cover is copyrighted by Wendall Macrae.

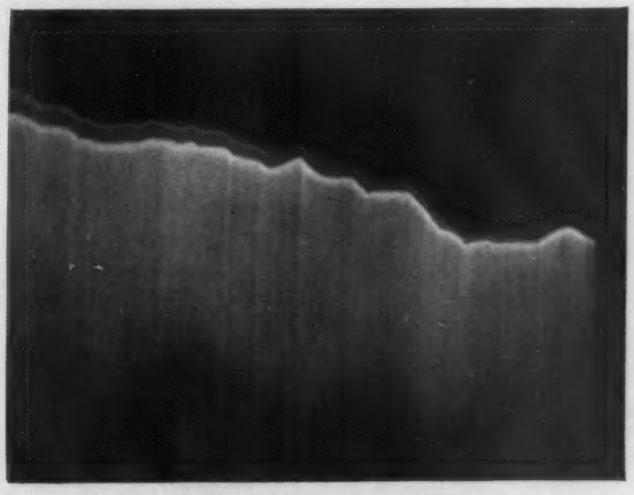
MAN-MADE LIGHTNING

TWELVE and one-half million kilowatts—approximately equal to the average output of all utility supply stations at the present time—was produced at a demonstration in the high voltage engineering laboratory of a prominent electrical concern, by K. B. McEachron, research engineer in charge of high voltage practice. Five million volts were generated with a current of 50,000 amperes—the highest current ever obtained at high voltage.

Higher voltages have been generated, according to Mr. McEachron, who has produced ten-million-volt strokes, but the 50,000-ampere current in the latest demonstration is about twice the average value recorded in investigations made in recent years.

Mr. McEachron also explained, for the first time, a new theory disclosing that the brilliant lightning flash one observes during a storm is not a bolt from the sky, but a union of a cloud streamer with a similar one from the earth. He showed photographic evidence that streamers from four to eight feet long arise from the earth previous to the arrival of a leader from the clouds.

"When the voltage in the cloud reaches a certain degree, a streamer starts toward the earth in a hesitating manner, becoming longer after every stop," Mr. McEachron said.



"In a series of jumps this streamer approaches the earth. The earth prepares to receive this stroke as streamers begin to form on the earth's surface when the cloud streamer is but a few hundred feet away."

He explained how the cloud streamer, traveling with a fractional part of the speed of light, connected with one of the earth's streamers. "The action of the air currents and the falling drops of water separates the charges in the cloud which causes the flow of currents in the earth. Really, then," he concluded, "the electrical counterpart of the cloud charges is in the earth, and woe be unto the man or beast who is at the point where the earth charges meet the cloud streamer."

Although it is generally believed that lightning does not strike twice in the same place, Mr. McEachron presented photographs showing that it not only strikes twice but it may strike a dozen or more times in the same place and over the same path within one second's time. He indicated that fires are the more probable result of the multiple stroke consisting of a rapid succession of charges through the same object. The tremendous pressure generated during the passage of current, is what makes the noise which we know as thunder.

—College Press Service.

RESEARCH IN REVIEW

COURSE II — Mechanical Engineering

VARIOUS research projects are being carried out at the Institute in the field of the plasticity of metals under the supervision of Dr. C. W. MacGregor.

Among these may be mentioned an investigation of the stress-reduction of area relations during the necking down of tensile test bars of different metals. As a result of this investigation, a new law connecting the average true stress and the reduction of area in the necking stage of the tensile test was suggested and verified by experiment. This work is to be presented at the Annual Meeting of the American Institute of Mining and Metallurgical Engineers in New York City in February.

A study is being made of the twisting of round bars of various materials into the plastic state by Mr. J. A. Hrones. Making use of the plastic theory, the true shearing stress at fracture is compared with the tensile strength and the double shear strength. A determination of the plastically deformed areas in bars of cross-section other than circular is being made by using a special etching procedure. The method is being applied at the present time to shafts with key ways, splined shafts, large drills, etc.

A new plasticity laboratory has been started in room 35–039 for the purpose of the investigation of various fundamental problems in the metal forming processes. A special Schlieren method of photographing the effect of plastic deformation has been designed and is nearly completed. Plastically deformed areas on highly polished surfaces may be easily observed and photographed with this apparatus.

An additional research project has recently been carried through in the Department of Mechanical Engineering, namely, the construction and operation of a new type differential analyzer. This analyzer, based on a new principal suggested by Dr. N. Minorsky, when a member of the staff, has been designed under the general supervision of Dean Bush and Professor Hunsaker. Professor Fuller and Dr. C. W. MacGregor were in direct charge of the work. The actual construction was carried out by C. N. Henshaw as a doctor's thesis.

In this analyzer, a torsion pendulum is so arranged that its restoring torque can be regulated according to the desired function of time and displacement. The main part of the apparatus consists of two coils mounted on a vertical shaft which is suspended from a fine steel wire. Each coil is surrounded by a horizontal solenoid rigidly mounted upon the base of the apparatus. When electric currents flow through the coils and solenoids, the moving coils tend to orient themselves with their axes parallel to the axes of the stationary solenoids. If displaced from this position and released, the moving coil assembly will oscillate according to the equation of the torsion pendulum. A recording arm attached to the vertical shaft traces the graph of the motion upon a sheet of paper mounted on a drum rotating at a uniform rate. The recording is accomplished by means of an electric spark which produces a distinct graph upon the Stylograph paper used for this purpose.

The apparatus was adapted to the solution of the Mathieu equation, which is a second order differential equation with a spring parameter varying with time. It was then applied to the determination of the speed range for which dangerous oscillations would be built up in an electric locomotive driving mechanism.

COURSE II — Textiles

IN textiles, as in chemistry, food technology, mineralogy, spectroscopy, or bacteriology, the identification of the raw materials or components of compounds or mixtures is of fundamental importance, and, as in any of these other fields of investigation, the development of quick and satisfactory methods of analysis is being intensively pursued. To identify textile fibres, exact information as to the appearance of the details of structure of known specimens under the microscope is essential. For this reason the textile microscopy laboratory is engaged in the preparation of standard longitudinal and cross sectional mounts in triplicate of as complete a range of fibres as possible. Comparison of the unknown material, similarly prepared, with such standards of reference makes easier the solution of many problems presented by the industry. Preparation of longitudinal mounts is relatively easy and quick, but obtaining good cross sections has been a time-consuming operation. Joint efforts by workers at Technology and in certain government departments have made possible a technique recently perfected here for the very rapid sectioning of many different varieties of fibre. The technique, involving a simple razor blade and a newly designed fibre ejector microtome makes possible preparation, cutting, and mounting of cross sections in a matter of only a few minutes instead of hours or days.

As an example of the utility of the scheme, a recent case, where it was imperative to determine immediately the fibre content of a coat suspected of having been improperly labelled, is of interest. A cross section of the fibres from this garment, made in less than twenty minutes, shows that, instead of being 100% camel hair as claimed, a substantial amount of cleverly dyed delustered rayon filaments have been used in the yarns composing the fabric. Not only is the method of value in such cases as this, but it is of very great aid in the solution of problems of fibre structure and treatment because of the tremendous saving in time and expense which it makes possible. More and better sections may now be more easily obtained than has ever been possible before.

COURSE V — Chemistry

FOUR years ago, Harold T. Gerry, '29, and Professor L. J. Gillespie published a theory for calculating the normal vapor pressure of slightly volatile substances from data obtained by indirect methods, for example, the gas-current scheme for determining the vapor pressure of such substances. They were able to test this theory by means of the available accurate data on iodine. They found that their corrections for deviations from the laws of ideal gases were numerically important in the case of the best of the indirect high precision methods.

The normal vapor pressure of iodine is the pressure of its pure vapor in equilibrium with pure crystalline iodine, under the pressure of that pure vapor, only. A few attempts had been made by previous investigators to measure the normal vapor pressure of iodine directly. The precision of none of these was within the theoretical uncertainties of the indirect methods where, necessarily, the assumption is made that iodine vapor behaves like an ideal gas and that mixtures of iodine and nitrogen, for example, behave as an ideal gas mixture. It was desirable to make measurements of high precision on the normal vapor pressure of solid iodine where un-

certainties because of mixtures would be eliminated.

The November, 1936, issue of the *Journal of the American Chemical Society* contains an article by Professor L. J. Gillespie and L. H. D. Fraser, Ph.D.'34, giving direct measurements of the normal vapor pressure of crystalline iodine. The data were obtained by means of a diaphragm pressure balance connected with a manometer capable of measuring low pressure accurately. The diaphragm was constructed of a sheet of platinum-rhodium foil (4% RL) 0.01 mm. thick, so mounted between two brass rings that it could be stretched and kept free from wrinkles in much the same manner as a drum head. Pure iodine vapor at a definite temperature was on one side of the diaphragm, and dry air, under a pressure (measured by the manometer) just balancing the iodine vapor pressure, was on the other side. An indicator, made of a light fiber of glass, cemented to the airside of the diaphragm, served to observe the position of equilibrium between the two pressures. The sensitivity of the diaphragm was found to be better than 0.004 mm. of mercury pressure. Iodine was observed not to corrode the platinum-rhodium alloy and a sufficient further protection against corrosion was obtained by gold plating all brass parts of the apparatus which came into direct contact with the halogen.

The normal vapor pressure of solid iodine was determined in this apparatus at 30°, 40°, and 60° Centigrade, with a precision greater than 0.22 percent. The results of these direct measurements were found to agree very well with the values calculated by the equation developed previously by Gerry and Gillespie, which takes into account the failure of the ideal gas laws for the gas mixtures employed in the indirect methods.

A notion of the magnitude of the effects measured can be gained from the fact that the normal vapor pressure of iodine at 30°C is only 0.467 mm.

THERE are many different types of thermometers among which may be mentioned mercury-in-glass, thermocouples, resistance, optical, and pyrometers. All of these instruments agree approximately on the indicated value of a certain temperature, and all agree as to whether a certain temperature is higher, the same, or lower than another; but no two thermometers of different type read on the same scale of temperature. The differences may amount to from 0.01°C to 1°C or more, depending on the region of temperature under investigation.

In the correlation of thermal data it is a matter of considerable importance to determine if one scale of temperature is of more fundamental importance than all others. This matter was settled by the theoretical investigations of Carnot, Clansins, and Kelvin, who showed that the idea of the impossibility of perpetual motion of the first and second kinds lead to a scale of temperature which is closely related to the maximum conceivable efficiency of a heat engine operating between a given boiler temperature and a given condenser temperature. This "absolute" or thermodynamic scale, is familiar to all who have studied the properties of gases, since it is used in the measurement of the temperatures that appear in the ideal gas law, $P^V = RT$.

The measurement of the absolute temperature of any fixed point, as the normal boiling of mercury, presents exceptional experimental difficulties.

The difficulties of realizing experimentally the ideal conditions for determining absolute temperatures led to the adoption by an international committee of an "international temperature scale." This scale was designed to agree as closely as possible with the absolute scale in so far as the latter was known and yet be reproduced in different laboratories with comparative ease. In the temperature range from 0 degrees to 660 degrees Centigrade, the international scale is based on the indicators of a calibrated platinum resistance thermometer.

For some years the Chemistry Department has been working on the problem of the actual reproducibility of the international scale when different platinum resistance thermometers are used and on the relation of the international to the absolute scale. The temperature readings of platinum resistance thermometers made from different samples of wire all of the specified purity were compared at many temperatures between 0 degrees and 450 degrees Centigrade. Agreement to 0.01 degrees Centigrade was obtained. If better agreement is desired it is necessary to introduce a fourth calibration temperature, and for this we suggest the boiling point of mercury, 356.58 degrees Centigrade, which we have determined very exactly.

We have found that although the international scale was reproducible to 0.01 degree Centigrade, it differed from the absolute scale by as much as 0.1 degrees Centigrade at 450 degrees Centigrade. This was determined by comparison of the readings of platinum thermometers with those of constant volume nitrogen gas thermometers. Nitrogen gas was confined in quartz vessels of one liter capacity, which were connected by means of fine quartz and steel capillaries to a mercury manometer. Such a gas thermometer differs from an idealized gas thermometer in that nitrogen is not an ideal gas. The volume of the vessel changes with temperature and pressure, and part of the gas is not at the temperature being measured. Corrections must be applied for all of these effects, for the capillary depression of mercury in the manometer, and the change in density of mercury with temperature and pressure. Since we desire to measure pressures to 1 part in 1,000,000 the effects of all the corrections must be carefully considered and determined.

A third result of the work is the determination of the position of the absolute zero on the Centigrade scale. Our value, –273.19 degrees Centigrade, is almost 0.1 degrees Centigrade larger than the value in general use up to a few years ago.

COURSE VIII — Physics

A paper on "Recent Progress in the Study of Radium Poisoning" was delivered by Dr. Robley D. Evans, of the Department of Physics, in the cancer symposium at the annual meeting of the American Association for the Advancement of Science, held recently in Atlantic City. Following is an abstract from the paper.

"RADIUM poisoning is not the effect of radium cancer treatments as usually given, but is the result of swallowing, breathing, or injection of radium, which is followed by partial storage in the bones of the body. The high incidence of sarcoma in cases of chronic radium poisoning points to some relationship between the diseases.

"Quantitative analytical studies of the amount of radium contained in a living victim of radium poisoning are essential to the development of a treatment for this disorder when sarcoma is not present. Very sensitive detectors of gamma radiation have been developed which permit quantitative observations on living patients containing less than one millionth of a gram of radium. In addition to the gamma rays from radium in the bones, the radon exhaled in the expired air originates from radium stored in the body, and accounts for about 44 percent of the total radium. The rate of loss of radium by the patient is directly measured by radium analyses of the body wastes, while the mobilization of radium within the body is studied by radon analyses of specimens of blood and of alveolar air.

"In collaboration with Dr. J. C. Aub, of the Collis P. Huntington Memorial Hospital, Boston, the detailed effects of medication similar to that developed for lead poisoning have been studied in three cases.

"In collaboration with Dr. J. W. M. Bunker, head of research in the Department of Biology and Public Health at the Massachusetts Institute of Technology, experiments on chronic radium poisoning in small animals are in progress in order to determine the limits of human tolerance to radium consumed in drugs and nostrums."

PHILOSOPHY

(*Continued from page 193*)

method of thinking.

Another of geology's gifts to philosophy lies in the revelation of the earth's energy. Many of our thoughts about the future of the world and of life have been based upon the thesis that the earth is dying—that its original inheritance of heat-energy is being spent, never to be replenished. As the moon no longer makes mountains or erupts lava or sustains life—if life ever were there—so the earth will one day cease to heave its crust; and after the rivers have worn away the last mountains, the ocean waves will gradually beat down the low remnants of continents and a sea will flow over the whole world.

But when we plot the actual history of mountain-building, volcanism, and continental movements, we see no sign of any diminution in earth-energy during the 1500 million years of legible geologic history. If the earth is really dying, its rate of loss of heat is so slow that there'll be abundant time even to pay our debts before the world ends.

An equally encouraging philosophy is offered about life; for now we know that evolution is very slow—so slow, when plotted upon the immensity of geologic time, that we need have no fear of sudden extinction, even if we must give up hope of rapid improvement in the near future.

INDICATORS

(*Continued from page 195*)

It may occur to some people that indicators have to be very sensitive to detect small changes in pH. The truth of such a belief is well borne out by the example of brom thymol blue having a concentration of .04 of 1 percent. The act of blowing over the mouth of an open bottle of ammonium hydroxide towards a solution of brom thymol blue is enough to turn the indicator a very definite blue. If now, this solution is poured from container to container, the amount of carbon dioxide absorbed from the air is enough to make the solution acidic, turning the indicator yellow.

So far, nothing has been said of the practical uses of indicators. The effect of pH in the preparation of hydroxides, basic salts, phosphates, silicates, and carbonates is well known. Some outstanding examples are the separation of the copper-arsenic group from the aluminum-zinc group at pH 4 to 6,

(*Continued on page 203*)

E. D. ABBOTT COMPANY
PRINTERS
181 Massachusetts Avenue, Boston, Mass.
KENmore 4051 and 3277

New England Distributors
SHELBY
Seamless Steel Tubing
NATIONAL—SHELBY
Seamless Steel Boiler Tubes
Austin-Hastings Co., Inc.
226 Binney Street Cambridge, Mass.
Telephone KIRkland 4480

When you want your car serviced by men who know how, coupled with the proper equipment, you will make no mistake in bringing it to us.
For years we have been rendering service to both members of the faculty and students at M. I. T.
Located near by at 306 Massachusetts Avenue.
We have live storage facilities for a limited number of cars for any who are interested.
RYAN & McMATH CO. **KIRkland 2020** **306 Mass. Ave.**

DORM MEN!!!
Blue and hungry late at nite,
Then that tired feeling comes.
Satisfy your appetite
With our coffee and our buns.

GRILL DINER
Situated 87.3′ N 3° 18′ E of Walcott — or to Freshmen
435 MAIN STREET
Come to get
The Best for the Least

INDICATORS

(*Continued from page 202*)

the precipitation of zinc as a sulphide at pH 2, and of aluminum at six to seven. All titrations with acids or bases involve an adjustment of pH, necessitating the proper selection of indicators. In many cases indicators can detect impurities in salts and other chemicals.

pH control is a very vital thing in cleansing processes. In laundry work a pH of from 9 to 11.5, depending upon the soap and the water supply, is usual. Rinsing causes the pH to drop to the pH of the water supply. A high pH must be avoided with silks, woolens, and certain cotton goods, where traces of alkiline salts may cause yellowing in ironing. Too high alkilinity causes fabrics to fall apart as is apparent to any one who has received a garment from the laundry with a large hole in the garment. Excess acidity may cause tendering of the fabrics; therefore a pH of 5 in extracter water is recommended. A moderately high pH of cleaners or soaps used on paint, varnish, or linoleum will remove the gloss, whereas a high pH will soon remove the paint entirely. It does not require too much perspicacity to observe that the pH of cleansers must be carefully regulated, again requiring the use of indicators.

Bacteria and other microscopic growths have certain optimum pH ranges for best growth and metabolism. (Molds, 1.5–8.5; Yeasts, 2.5–8.0; Bacteria, 4–7.5). Each species has a fairly narrow range for best growth, thus providing a convenient means of identifying species, separating groups, and isolating pure cultures. The disinfectant action of acids and bases is often dependent upon pH, as are also the production of enzymes, toxins, and immune substances. Industrially, pH control is applied to brewing and the manufacturing of alcohol, vinegar, cheese, and yeast. Some convenient indicators for these ranges are thymol blue, bromphenol blue, methyl red, bromthymol blue, and phenol red. Small portions of the material are treated with the proper indicators, and from the color changes the pH values are apparent.

(*Continued on page 204*)

CONTAX III

With Built-in Photoelectric Exposure Meter

Embodied within the camera, instant and accurate provision for determining correct exposure and focus . . . the twin factors in assuring good negatives.

See the Contax III at your dealers.
Write for illustrated booklet.

CARL ZEISS, INC., 485 FIFTH AVE., NEW YORK
728 So. Hill Street, Los Angeles

BERKELEY PREPARATORY SCHOOL

(Established 1907)

An Accredited School

Preparation for all colleges and technical schools; entrance by certificate or examination.
Day and Evening Sessions.

SEND FOR CATALOG

1089 BOYLSTON STREET, BOSTON **Tel. COM. 9262**

SIMPLEX WIRES and CABLES

for electrical transmission

Insulated with Rubber, Paper or Cambric

SIMPLEX WIRE & CABLE CO.
79 Sidney Street, Cambridge A
BOSTON, MASS.

INDICATORS

(*Continued from page 203*)

The pH of the human blood is from 7.3 to 7.5, generally averaging about 7.4. As Dr. A. R. Davis has said, "Life may begin at 40, but not on the pH scale. There it begins at 7.3." Any great deviations in the pH of the blood from the above values will cause death. One notices that the pH of the blood is very nearly neutral, although it is slightly on the basic side. A tentative hypothesis states that the respiratory center is sensitive to changes in pH, lung ventilation being stimulated by a decrease of pH, and checked by an increase of pH. The gastric contents of the stomach have a pH of from 1–3, a very acidic value, while human feces have a pH of from 4.6–8.4.

Properly regulated pH values of foods is essential in the food industry. Different types of bread, for instance, have optimum pH values for the best volume, texture, and color. Age decreases the time necessary for fermentation, by reducing the pH of the flour. Crackers with an excess of soda are brown and burned, and their volume is too great for the usual containers. Dough with a pH of 7.1 is usually satisfactory. In the canning industry the time and temperature necessary for properly preserving foods is materially affected by pH. For the common fruits (under 4) a light process is satisfactory. Carrots, beets, and beans (5.0–6.0) require a heavy process, while a very heavy process is needed for corn, peas, and meat (pH over 6.0). The taste of foods is often influenced by pH, as is evident by the sour taste of lemons. Jelly formation is controlled by adjusting the pH of the fruit juices used in the process. Above a pH of 3.6, the jelly will not form; but a drop to pH 3 causes an increase of the strength of the jelly. Below pH 3 sweating tends to occur. Of course, indicators are widely used industrially in making food products, but we cannot expect their use by housewives. The housewife manages to get good products as a result of her experience, but such a procedure by manufacturers not only wastes time, but causes needless expenditures. Again is seen a great field for the use of indicators.

We now turn to the action of buffers, this action being quite important in conjunction with the use of indicators. In 1900, Fernbach and Hubert noticed the power of certain solutions of resisting a change in reaction. They compared this action as displayed by phosphate solutions to a tampon. Sorensen adopted this term, and in his classic paper of 1909 appeared the word "puffer" as the German rendition of tampon. In English the word is known as buffer. Simply stated, buffer action is the opposition offered by certain solutions to changes of pH which might be brought about by the addition of an acid or a base. A buffer solution usually consists of a mixture of a weak acid and a salt of that acid, or a weak base and a salt of that base. When an acid is added to a solution buffered with a weak acid and its salt, the added acid combines with the salt of the buffer forming a weak acid. As weak acids are very little ionized, the pH value remains very nearly constant. Perhaps the following example may help to clarify the explanation. Pure water has a pH of 7. If one cubic centimeter of .01 N hydrochloric acid is added to a liter of water the pH will change approximately to 5, a considerable deviation, as the volume of added acid is only $\frac{1}{1000}$ that of the total solution.

To be of any especial importance, a chemical reagent or a class of reagents must have some practical applications, and not be merely an interesting laboratory experiment. Indicators are certainly of definite value, as we have seen in their use in bacteriology, cleaning processes, chemical analysis, food industries, and biology. It is the co-operation between experimenters and theorists in one sphere, and practitioners in another sphere that makes science of true value to the world.

Howard JOHNSON'S

Home made
ICE CREAM — CANDIES
PASTRIES
LUNCHEON & DINNER SERVED
.50c .75c and $1.00
VISIT OUR
Knotty Pine Dining Room
-- *JOIN US AT* --
Howard Johnson's
540 Memorial Drive, Cambridge
KIRkland 5269

RADIO
COMPONENTS AND ACCESSORIES
TUBES OF ALL TYPES
Speedy and Courteous Service
New England Distributors for

Aerovox	Mallory-Yaxley
Hammarlund	National
International Resist	R. C. A.
Thordarson	Jensen Speakers

Presto Recorders and Discs, etc.
Inquiries solicited
H. JAPPE COMPANY
46 Cornhill, Boston, Mass.
LAF. 0510-0511
Worcester, Mass. Dover, N. H.

SAMSON SPOT SASH CORD

Trade-Mark Registered U. S. Patent Office
Made of extra quality cotton yarn, carefully inspected, and guaranteed free from all imperfections of braid or finish.
The colored spots are our trade-mark, used only with this quality.
We make braided cord of all sizes, kinds, and colors for all purposes, including sash cord, clothes lines, trolley cord, signal cord, arc lamp cord, and many special cords for special purposes; also cotton twines.
CATALOGUE AND SAMPLES GLADLY SENT ON REQUEST
SAMSON CORDAGE WORKS 89 Broad Street, Boston 9, Mass.

THE TECH ENGINEERING NEWS

INDEX—Volume XVI

MARCH 1935—FEBRUARY 1936

Subject and Author	*Month*	*Page*
ABSOLUTE ZERO Hess, James B., '38	March	10
AIRLINE OPERATION Rickenbacker, Capt. E. V.	November	163
AIRPLANES FOR PRIVATE OWNERS Geisse, John H.	January	141
ALADDIN'S LAMP—THE ELECTRON TUBE Krim, Norman B., '34	May	46
ATOMIC TRANSMUTATION, MODERN Dolbin, Milton B.	January	135
BENNETT, RALPH D. A Mystery of the Universe	April	31
BOOGE, J. E., and GILLSON, J. L. Titanium Pigments	December	121
BOSSANGE, EDWARD R. Soya	January	143
BRITISH BROADCASTING Eckersley, P. P.	November	91
BUILDING COLLAPSES Miller, Rudolph P.	November	96
BUSH, VANNEVAR Hobbies	November	89
BUSINESS ADMINISTRATORS Schell, Erwin H., '12	May	43
CANCER Morton, Avery A.	February	147
CHINESE ALCHEMISTS, EARLY Davis, Tenney L.	March	3
CHROMIUM—PAST AND PRESENT Weston, C. E.	November	94
CITY HOUSE OF WILLIAM LESCAZE Lescaze, William	June	65
COHEN, PAUL, '35 Scrap Iron	January	138
COLLOIDAL ENGINEER, THE Hauser, E. A.	December	113
COLOR Hardy, Arthur C.	February	159
COTTON, NEW USES FOR Everett, Charles K.	November	99
DAVIS, TENNEY L. Early Chinese Alchemists	March	3
DEL BOURGO, J. J. Lateral Pressures	December	119
DINOSAURS Shirley, Paul, Jr., '38	December	115
DOLBIN, MILTON B. Modern Atomic Transmutation	January	135
DUPRENE Nieuwland, Rev. Julius A.	June	70
ECKERSLEY, P. P. British Broadcasting	November	91
ELECTRON TUBE, THE—ALADDIN'S LAMP Krim, Norman B., '34	May	46
ENERGY IN RADIATION Wilkes, Gordon B., '11	April	26
ENGINEER—SELL YOURSELF Hill, T. Russ	April	35
ENGINEERING FEATURES OF THE 1935 AUTOMOBILE Powell, S. Curtis, '37	March	6
EVERETT, CHARLES K. New Uses for Cotton	November	99
"FROSTBITE" DINGHIES Owen, George, '94	February	167
GEISSE, JOHN H. Airplanes for Private Owners	January	141
GILLSON, J. L., and BOOGE, J. E. Titanium Pigments	December	11
HARDY, ARTHUR C. Color	February	159
HAUSER, E. A. The Colloidal Engineer	December	113
HERITAGE OF FABRIC, THE Schwarz, E. R., '23	May	50
HESS, JAMES B., '38 Absolute Zero	March	10
HIGH SPEED ENGINES Strickland, Randolph L., '35	June	75
HILL, RUSS T. Engineer—Sell Yourself	April	23
HOBBIES Bush, Vannevar	November	89
KENDRICK, JAMES B., '34 Modern Soaring Flight	April	28
KRIM, NORMAN B., '34 Aladdin's Lamp—The Electron Tube	May	46
LATERAL PRESSURES Del Bourgo J. J.	December	119
LESCAZE, WILLIAM City House of William Lescaze	June	65
LOEB, CARL M., JR., '28 Molybdenum	June	68
MAGOUN, F. ALEXANDER Ruts of Stagnation	February	165
MILLER, RUDOLPH P. Building Collapses	November	96
MODERN ATOMIC TRANSMUTATION Dolbin, Milton B.	January	135
MODERN SOARING FLIGHT Kendrick, James B., '34	April	28
MOLYBDENUM Loeb, Carl M., Jr., '28	June	68
MOON, PARRY H. Protecting Your Eyes	March	8
MORTON, AVERY A. Cancer	February	157
MYSTERY OF THE UNIVERSE, A Bennett, Ralph D.	April	31
NEW USES FOR COTTON Everett, Charles K.	November	99
NIEUWLAND, REV. JULIUS A. Duprene	June	70
OWEN, GEORGE, '94 "Frostbite" Dinghies	February	167
PENDRY, G. EDWARD Rocketry	June	72
POWELL, S. CURTIS, '37 Engineering Features of the 1935 Automobile	March	6
PROTECTING YOUR EYES Moon, Parry H., '27	March	8
RICKENBACKER, CAPT. E. V. Airline Operation	February	163
ROCKETRY Pendray, G. Edward	June	72
RUTS OF STAGNATION Magoun, F. Alexander	February	160
SCHELL, ERWIN H., '12 Business Administrators	May	43
SCHWARZ, E. R., '23 The Heritage of Fabric	May	50
SCRAP IRON Cohen, Paul, '35	January	138
SHIRLEY, PAUL, JR., '38 Dinosaurs	December	115
SOLVING SIMULTANEOUS EQUATIONS Wilbur, John B., '26	May	48
SOYA Bossange, Edward R.	January	143
STRICKLAND, RANDOLPH L., '35 High Speed Engines	June	75
TITANIUM PIGMENTS Booge, J. E., and Gillson, J. L.	December	121
WESTON, C. E. Chromium—Past and Present	November	94
WILBUR, JOHN B., '26 Solving Simultaneous Equations	May	48
WILKES, GORDON B., '11 Energy In Radiation	April	26

THE TECH ENGINEERING NEWS

INDEX—Volume XVII

MARCH 1936—FEBRUARY 1937

Subject and Author	*Month*	*Page*
AIRCRAFT MANUFACTURERS S. Paul Johnston, '21	December	165
ATOM-PROBERS Professor George R. Harrison	May	61
BABSON, ROGER W. Statistics	November	131
BAKELITE Marc Cutler, '39	June	89
BLAST FURNACE Ralph H. Sweetser	March	5
CALDWELL, FRANK W., '12 Propeller Design	December	172
CAMP, PROFESSOR THOMAS R. Sanitary Engineering	November	133
CIVIL ENGINEER George T. Seabury	March	14
CIVIL ENGINEERING Professor John B. Wilbur	January	187
CLAPP, FREDERICK G. Geology	March	11
COOLIDGE X-RAY TUBE Millard B. Hodgson, '39	January	190
CRIME DETECTION J. Edgar Hoover	October	105
CUTLER, MARC, '39 Bakelite	June	89
CYANAMID Dr. Walter S. Landis	June	87
DAVIS, WATSON Research News	November	138
DIAMOND, THE Sten W. Wadsten	January	194
DONOVAN, JOSEPH J., '39 Miniature Photography	October	114
DRAPER, PROFESSOR CHARLES S., '26 Instruments	December	170
ENGINES Professor C. Fayette Taylor	December	159
ENGLISH AIRCRAFT INDUSTRY C. G. Grey	December	161
FRANKEL, DAVID S. Television	April	38
"FRISCO" BRIDGE Gordon A. Pope	March	9
FUTURE IN FOODS, A Professor Bernard E. Proctor	June	81
GEIER, FREDERICK V. Machine Tool Design	April	29
GEOLOGY Frederick G. Clapp	March	11
GREENHALGH, JOHN E. Pre-Fabricated Housing	October	109
GREY, C. G. English Aircraft Industry	December	161
HARRISON, PROFESSOR GEORGE R. Atom-Probers	May	61
HAYDEN, ARTHUR G. Rigid Frame Bridges	April	32
HODGSON, MILLARD B., '39 Coolidge X-ray Tube	January	190
HOOVER, J. EDGAR Crime Detection	October	105
INDICATORS Norman L. Laschever, '40	January	195
INSTRUMENTS Professor Charles S. Draper, '26	December	170
JACK, PROFESSOR JAMES R. Safety at Sea	May	64
JOHNSTON, S. PAUL, '21 Aircraft Manufacturers	December	165
KAEMPFFERT, WALDEMAR B. Science and the Press	May	53
KNUDSEN, WILLIAM S. Production and Management	May	56
LANDIS, DR. WALTER Cyanamid	June	87
LASCHEVER, NORMAN L. Indicators	January	195
LONDON TRANSPORT Especially written for the T. E. N.	June	83
MACHINE TOOL DESIGN Frederick V. Geier	April	29
MARSHALL, LOUIS The Young Chemist	June	92
MILAS, PROFESSOR NICHOLAS A. Vitamins	October	111
MILK INSPECTION James A. Tobey	May	99
MINIATURE PHOTOGRAPHY Joseph J. Donovan, '39	October	114
MORRIS, PROFESSOR FREDERICK K. A Scientist's Philosophy	January	193
PATENT APPLICATIONS A. A. Schaefer	April	37
PHILOSOPHY, A. SCIENTIST'S Professor Frederick K. Morris	January	193
POPE, GORDON A. "Frisco" Bridge	March	9
PRE-FABRICATED HOUSING John E. Greenhalgh	October	109
PROCTOR, PROFESSOR BERNARD E. A Future In Foods	June	81
PRODUCTION AND MANAGEMENT William S. Knudsen	May	56
PROPELLER DESIGN Frank W. Caldwell, '12	December	172
RESEARCH NEWS Watson Davis	November	138
RIGID FRAME BRIDGES Arthur G. Hayden	April	32
RUMSEY, JIM S. The Streamline Train	November	139
SAFETY AT SEA Professor James R. Jack	May	64
SANITARY ENGINEERING Professor Thomas R. Camp	November	133
SCHAEFER, A. A. Patent Applications	April	37
SCIENCE AND THE PRESS Waldemar B. Kaempffert	May	53
SEABURY, GEORGE T. Civil Engineer	March	14
STAINLESS STEEL Joseph Zallen	November	136
STATISTICS Roger W. Babson	November	131
STREAMLINE TRAIN, THE James S. Rumsey	November	139
SWEETSER, RALPH H. Blast Furnaces	March	5
TAYLOR, PROFESSOR C. FAYETTE Engines	December	159
TELEVISION David S. Frankel	April	38
TOBEY, JAMES A. Milk Inspection	May	59
VITAMINS Professor Nicholas A. Milas	October	111
WADSTEN, STEN W. Diamond, The	January	194
WILBUR, PROFESSOR JOHN B. Civil Engineering	January	187
YOUNG CHEMIST, THE Louis Marshall	June	92
ZALLEN, JOSEPH Stainless Steel	November	136

Even bare feet will never feel it!

OCCASIONALLY a telephone wire must be run under a rug or carpet. The twisted wire formerly used made an unsightly ridge.

So Western Electric—manufacturing, distributing and purchasing unit of the Bell System—produces a flat cord only one-eighth inch thick, seven-eighths of an inch wide. (Like this). Within this tiny space are four conductors of insulated wire. Under the rug or carpet this cord is not seen, not even felt with bare feet.

Even to the smallest detail, the Bell System is constantly on the lookout for the better way to make telephone service more satisfactory to the customer.

College men and women find after 7 P. M. a convenient time for long distance calling. Moreover, most rates are lowest then.

BELL TELEPHONE SYSTEM

G-E *Campus News*

LIGHTNING STRIKES TWICE

LIGHTNING may strike not only twice but a dozen times in the same place over the same path within one second's time. This is one of the unusual facts that Karl B. McEachron, Research Engineer of General Electric's High-voltage Laboratory, has found out about lightning.

Even more unusual is the new theory that the brilliant lightning flash one observes during a storm is not a bolt from the sky, but a union of a cloud streamer with a similar one from the earth. The action of the air currents and of the falling drops of water separates the charges in the cloud. When the voltage in the cloud reaches a certain value, a streamer starts toward the earth, traveling in jumps at about one-tenth the speed of light. When this streamer is a few hundred feet away, streamers from four to eight feet long begin to form on the surface of the earth. When the streamer from the clouds unites with one from the earth, the flash of lightning occurs. The pressure generated during the passage of current makes the thunder.

General Electric conducts research in lightning so that its engineers can design transmission lines and protective equipment which will insure better continuity of service.

UNIVERSITY CLUB

DAVE PACKARD of Stanford and Otto Schwartz of Columbia played against each other in the Rose Bowl game of 1934, but now they are working side by side in the Schenectady Works of the General Electric Company. This seems unusual until it is pointed out that in the General Electric organization is one of the largest and most cosmopolitan university clubs in the world. Approximately 4500 college graduates, representing 237 American universities, colleges, and technical schools, are employed by the Company. In addition, there are 198 graduates from universities in 22 foreign countries.

Ten educational institutions have contributed more than 100 graduates each to the General Electric family. They are: Cornell, Iowa State, M.I.T., Penn. State, Pratt Institute, Purdue, Union College, U. of Colorado, U. of Michigan, and Yale. Fifteen other schools have provided more than 50 graduates each. They are: Case School, Georgia Tech., Kansas State, U. of Maine, U. of Minnesota, Ohio State, R.P.I., Syracuse, U. of California, U. of Illinois, U. of Kansas, U. of Nebraska, U. of Wisconsin, V.P.I., and Worcester Polytechnic.

DETECTING LIES

PAPA WASHINGTON needed no lie detector; George told the truth. But as a check on less truthful persons, Northwestern University's crime-detection laboratory has developed a lie detector. It makes simultaneous measurements of respiration, blood pressure, and perspiration. Emotional disturbances are reflected in these body functions. And since extremely sensitive recording instruments are needed to record changes in perspiration, the delicate photoelectric recorder developed by General Electric engineers is put to work.

For many years General Electric has made instruments for exacting applications. This same photoelectric recorder is used to obtain a continuous record of temperature in a wire-enameling oven. Electric gauging of ball-bearing diameters, of wire diameters, and of strip thickness is accomplished in rolling mills. These operations and hundreds of others are recorded by this instrument, and with a power consumption of only one thousandth of a microwatt.

96-348DH

GENERAL ELECTRIC

The Kendall Printing Company

Company